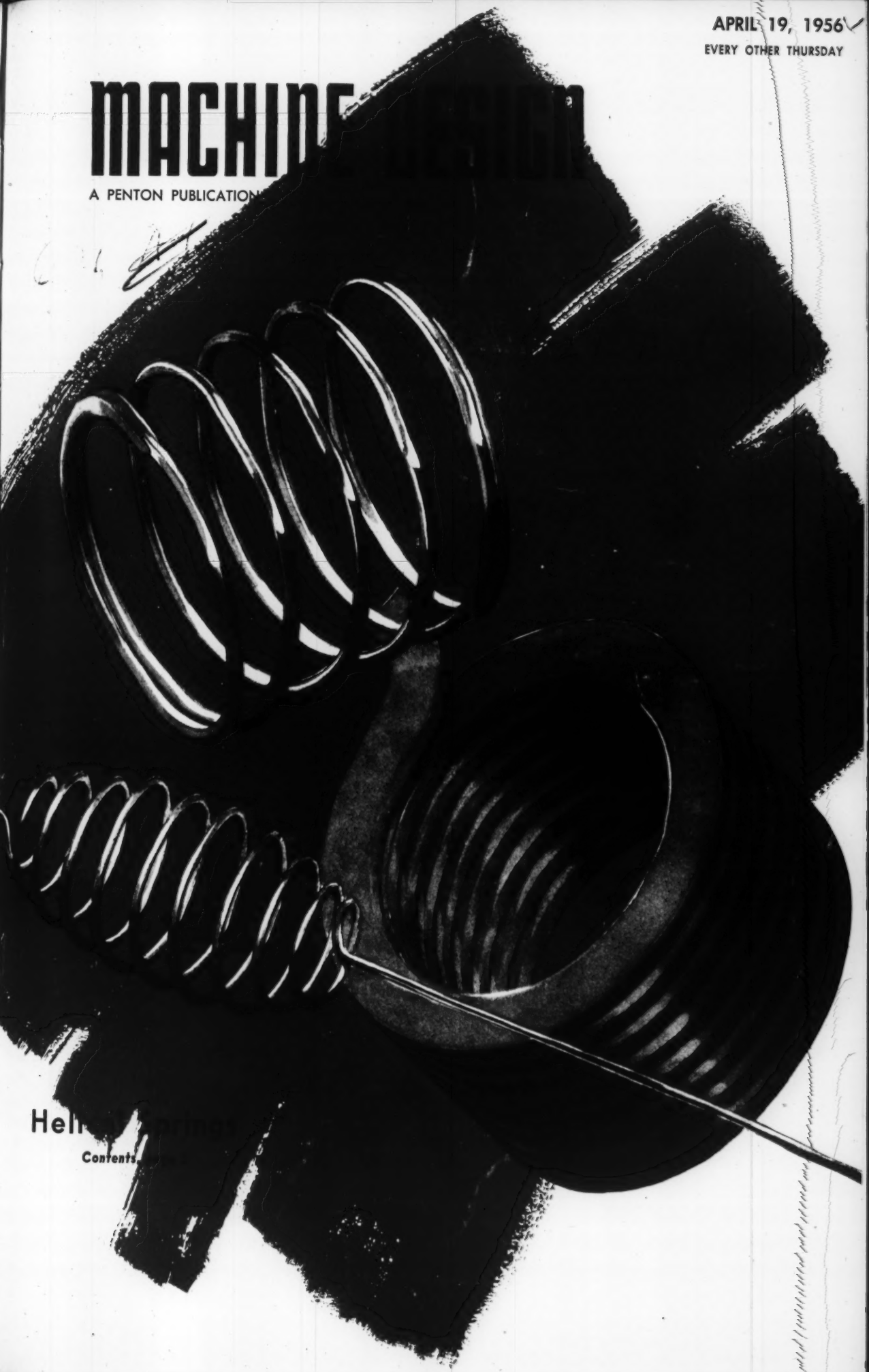
APRIL 19, 1956
EVERY OTHER THURSDAY

MACHINE

A PENTON PUBLICATION



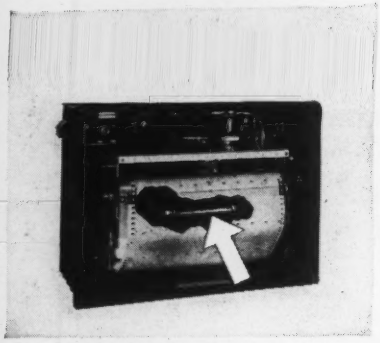
Hel

Contents

FLEXIBLE SHAFT IDEAS for ENGINEERS

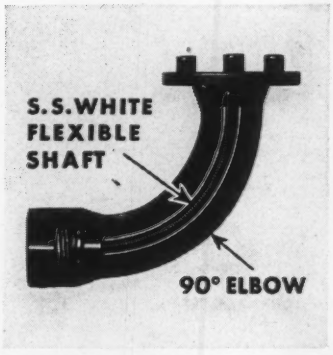
Flexible Shafts simplify manufacturing operations — lead to improved designs

Cost-savings possibilities are many when you design with these useful mechanical elements

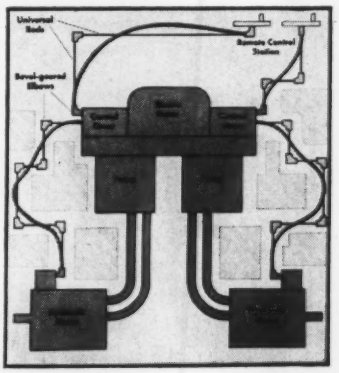


Giving alignment problems the "go-by"

NOT ONLY DOES a flexible shaft provide a vibrationless drive in this sensitive recording pyrometer, but it eliminates the need for accurate alignment of the connected spindles. The ability of a flexible shaft to operate under conditions of misalignment is a feature that is of extreme importance in many remote control and power drive installations.



A truck recorder drive in which a 3" flexible shaft replaced a set of bevel gears and straight shafts. Result: fewer parts, lower cost and elimination of failures caused by high starting torque of the gears.



4 standard flexible shafts replaced the 35 parts formerly used to control this dual hydraulic power unit. Result: a 90% cost savings and 100% improved performance.

NO OTHER SINGLE MECHANICAL ELEMENT solves power drive and remote control problems as simply and economically as an S.S.White flexible shaft.

Savings through Simplification

For instance, the ability of an S.S.White flexible shaft to operate around turns and under conditions of misalignment is a big help in simplifying drive or control setups. It means that a single flexible shaft can often be used in place of whole systems of bevel and worm gears, solid shafts, universals, etc. Naturally, with fewer parts to handle, production time and costs can be trimmed.

Improved Designs

Simplification is not the only advantage offered by an S.S.White flexible shaft. It gives greater leeway in locating coupled parts to insure greater efficiency, easier operation, greater compactness, or more attractive appearance.

Reduced Layout Time

Not the least of a flexible shaft's advantages, is the ease with which it can be applied. There are no gear ratios to work out—no alignment problems—no worries about tolerances on bearing and journal fits, about special machining, etc. And, the wide range of physical characteristics and sizes available, make it easy to meet a diversity of requirements.

Here is a bulletin every designer should have

Bulletin 5601 contains the latest information on flexible shafts. Included are full details on how to select and apply power drive and remote control flexible shafts as well as up-to-date tables showing flexible shaft sizes and characteristics. Send for a copy.

F6-4

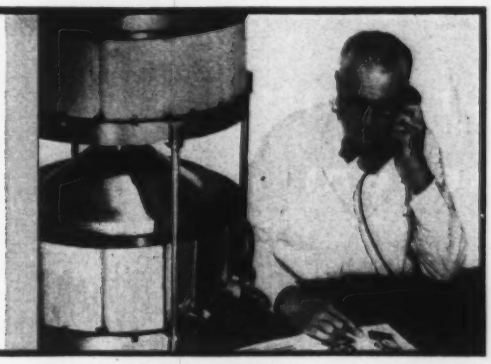
FIRST NAME IN FLEXIBLE SHAFTS

S.S.White

S. S. WHITE INDUSTRIAL DIVISION, DEPT. 4, 10 EAST 40th ST., NEW YORK 16, N.Y.

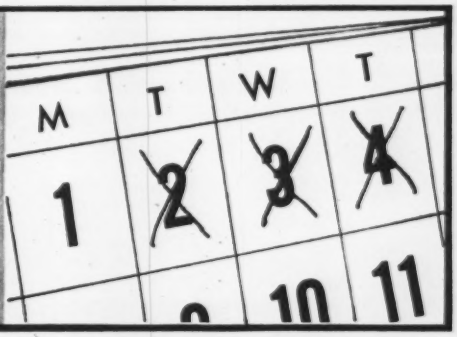
Western Office: 1839 West Pico Blvd., Los Angeles 6, Calif.

Why Bodine motors were selected for the new model Autotechnicon

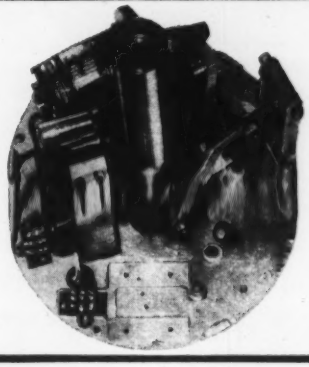


1 This is the newest model of the "Autotechnicon." It's used in preparing microslides from tissue removed from patients during surgery.

2 After processing, the slides are viewed under a microscope...the only manner in which positive diagnosis of cancer can be made.



3 The "Autotechnicon" prepares tissue specimens in only 24 hours...four times as fast as a hospital technician would do it by hand.



4 The two motors used to power this vital piece of equipment are Bodine Motors...a Type NSI-12RG and a Type KCI-22RM.

5 This is Mr. Edwin C. Weiskopf, president of the Technicon Company, manufacturers of various types of Autotechnicons since 1930.

"We decided on Bodine Motors ...because we felt they were the most dependable and best made motors we could obtain. This is important since the proper functioning of the apparatus often means the difference between life and death. If the machine should not function and the tissue be destroyed, the patient might have to undergo surgery again ...an impractical procedure to say the least."

BODINE

BODINE

fractional horsepower

MOTORS

6 Mr. Weiskopf tells why his company uses Bodine Motors to power the "Autotechnicon" ...see above.

7 Be sure your motor is as good as your product. For detailed information, write Bodine Electric Company, 2258 W. Ohio Street, Chicago, Illinois.

—ITEM 554—

BODINE MANUFACTURES FRACTIONAL HORSEPOWER ELECTRIC MOTORS

FOR:

adding machines
letter openers
sanders
vending machines
exhaust fans
duplicating machines
portable tools
sound recorders
air conditioners
check protectors
respirators
voltage regulators
x-ray timers
traffic signal timers
stirrers
calculating machines
envelope sealers
diesel governors

...and for many other applications.

Ask for a sample copy of "The Motorgram," a bi-monthly publication discussing the application and design of fractional horsepower electric motors.

Bet your boots we make 'em

Steering knuckle drag link boot
Universal joint cover
C/R
Bellows cover for sliding ways
Coated fabric cylinder rod boot
Hydraulic jack cylinder rod boot

Custom-designed and engineered to fit mechanical giants or midgets

Whether you want a boot two stories high . . . or no bigger than your thumb . . . let C/R Sirvis engineers solve the problem for you. They're specialists . . . backed by 78 years' experience . . . with unusual skills and ingenuity in the development and manufacture of mechanical boots. They'll design and produce a C/R Sirvis boot to your exact requirements in any size, any quantity . . . using only the finest materials: mechanical leather, selected, tanned and treated by C/R . . . nylon . . . or elastomer-coated fabric. The absolute dependability of your boot will be proved before production.

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1221 Elston Avenue • Chicago, Illinois

Offices in 55 principal cities. See your telephone book.

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Export Sales: Geon International Corp., Great Neck, New York

SIRVIS C/R DIVISION
CHICAGO RAWHIDE

Other C/R Products
C/R Shaft & End Face Seals • Sirvene (synthetic rubber) molded pliable parts • C/R Non-metallic Gears

—ITEM 555—
For More Information Circle Item Number on Yellow Card—page 19

THE PROFESSIONAL JOURNAL
FOR ENGINEERS AND DESIGNERS

MACHINE DESIGN

April 19, 1956
Volume 28—No. 8

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$\frac{T^P + F}{H^e} = YS$

use the SYNCHRON* formula to solve your timing problem

The Synchron Formula can help you cut production costs, make designs *work* the way you plan them.

Apply it to your timing problem. Gather the factors . . . T^P, the *Timing Problem*, plus F, the *Facts* (proposed mounting methods and a simple sketch). Send this data to the denominator in our equation . . . H^e, the *Hansen Engineering Department*.

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You'll find the Synchron Formula an easy way to the solution of your timing motor problem. Hansen Engineers are specialists; learn to rely on their 48 yrs. of experience designing, building, testing, and specifying timing motors for every type of application.

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*SYNCHRON synchronous motors operate smoothly, evenly in any position; at temperatures from −40° to +140° F.; start instantly under load; pull up to 20 in. oz. at 1 RPM. Available in 42 speeds from 0.8 RPM to 600 RPM.

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FACTORY REPRESENTATIVES: *The Fromm Co., 5254 W. Madison St., Chicago, Ill. • R. H. Winslow • Assoc. 123 E. 37th St., New York, N. Y. • Electric Motor Engineering, Inc., 8255 Beverly Blvd., Los Angeles, Cal. • Lawrence Sales Co., Box 13026, Dallas, Texas*

—ITEM 556—

Engineering News Roundup

Chairmen Announced For First Design Conference

Growing List of Companies To Display Equipment

PHILADELPHIA, PA. — Recent announcements show a steady increase in the number of manufacturers who will display equipment and services at the country's first Design Engineering Show and Conference on May 14 to 17.

Also recently announced are the names of the chairmen of the four technical sessions, sponsored by the Machine Design Div. of the American Society of Mechanical Engineers. Following are the session chairmen:

Monday, May 14

Session I—*Value Analysis in Product Design.* Chairman: Victor Sepavich, Director of Engineering, Crompton and Knowles Loom Works. Vice Chairman: H. R. Clauser, Editor, *Materials and Methods.*

Tuesday, May 15

Session II—*How to Get and Train Design Engineers.* Chairman: Philip R. Marvin, Consultant, American Viscose Corp., Philadelphia. Vice Chairman: Colin Carmichael, Editor, MACHINE DESIGN.

Wednesday, May 16

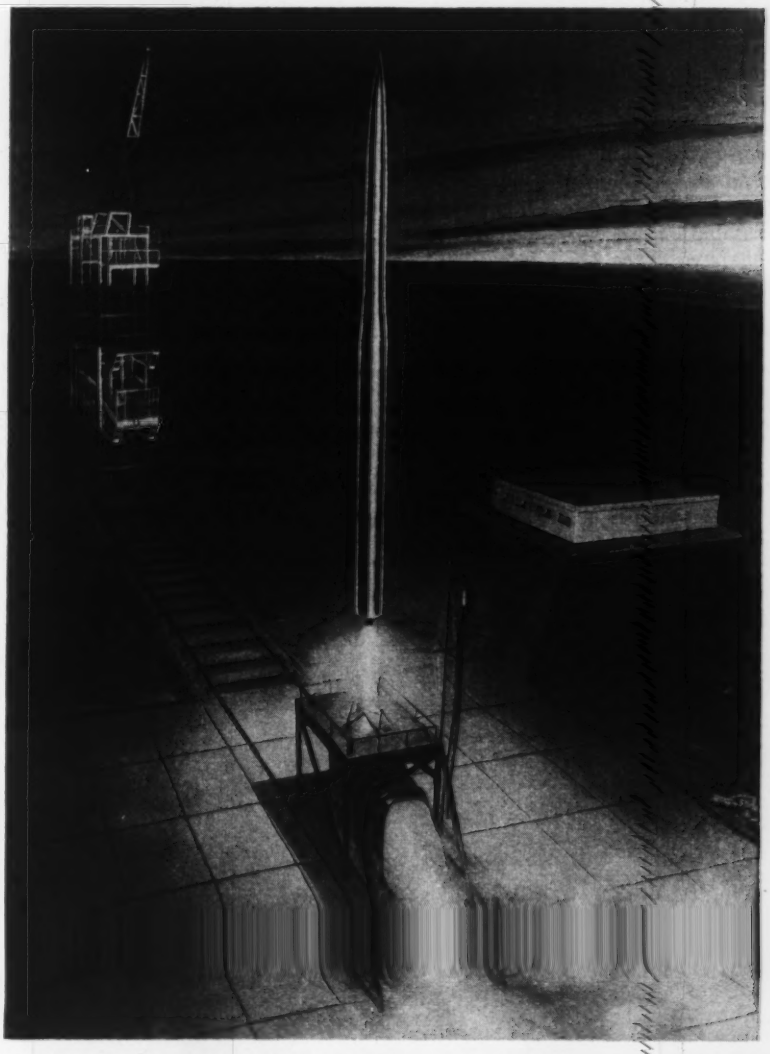
Session III — *Selecting Engineering Materials for Products* and *Problems in Miniaturization.* Chairman: Clifford Eddison, Manager, Chemistry & Physics Laboratory, Radio Corporation of America, Camden, N. J. Vice Chairman: Frank J. Oliver, Editor, *Electrical Manufacturing.*

Thursday, May 17

Session IV: *Recognition and Reward for Invention* and *Rights of the Employees' Inventions.* Chairman: Donald G. Fink, Director of Research and Development, Philco Corp., Philadelphia. Vice Chairman: Frank Piasecki, President, Piasecki Aircraft, Philadelphia.

In the technical sessions, the chairmen will introduce prominent speakers intimately concerned with subjects which are equally important to design engineers. Further information on the conference is available from the ASME, 29 West 39th St., New York, N.Y. Conference registrations will be accepted in Convention Hall, Philadelphia, at the start of the four-day session.

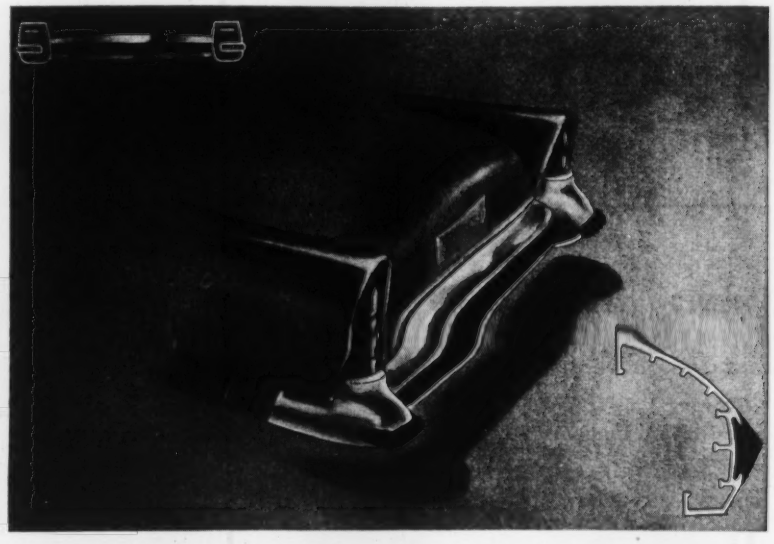
The variety and number of company displays already scheduled indicate that the show in connection with the conference will be a valuable experience for designers and engineering executives. In-



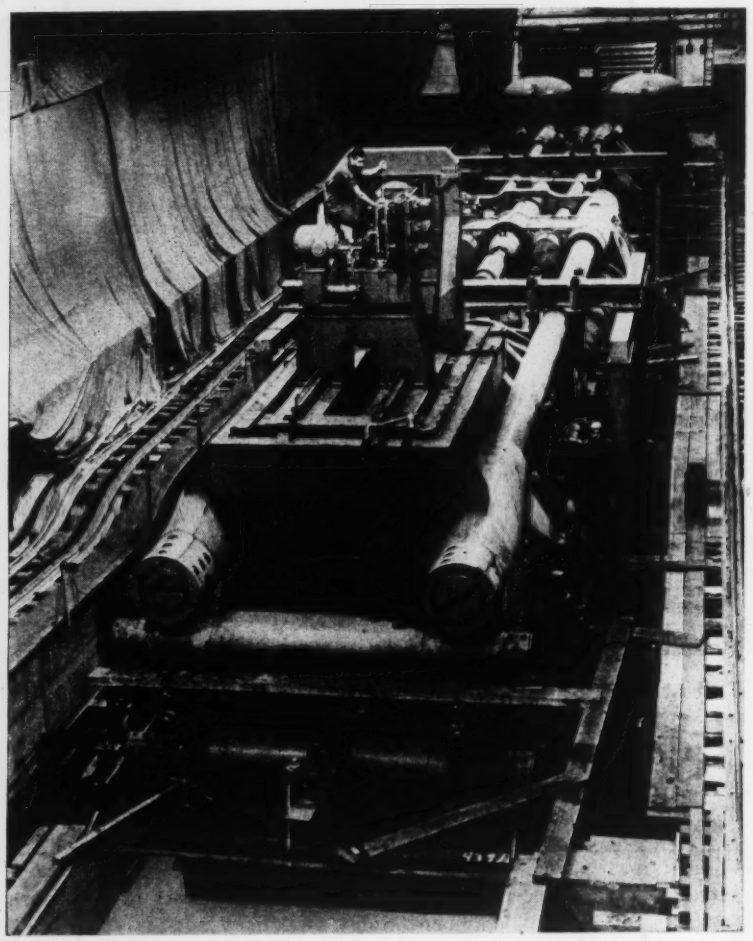
BIG BULLET, self-propelled, is the Navy *Vanguard* shown as it will be launched to carry the first man-made earth satellite to its orbit. The Martin Co., Baltimore, is prime contractor for the three-stage vehicle. The first rocket stage, 45 ft long, will carry the entire assembly up 30 to 40 miles. The second stage, enclosing the third, will fire, then coast to the orbit. Third stage delivers satellite to the orbit at a speed of 18,000 mph

dividual registrations for the show can be obtained from Clapp & Poliak Inc., 341 Madison Ave., New York 17, N. Y.

Ersatz motor that neither runs nor wears out is used by Minneapolis-Honeywell engineers in testing switches and relays. An arrangement of resistors and inductors that duplicates the electrical behavior of a real motor, the substitute can't wear out because it has no moving parts. It is used because real motors wore out faster than the equipment being tested. The device is right at home in its installation in a fully furnished uninhabited house which is used only for engineering tests.



RUBBER BUGGY BUMPERS for automobiles, held in place by anodized aluminum extrusions, are proposed by Reynolds Metals Co. The bumper assembly combines an extruded midsection with cast aluminum end pieces



FIRST WEST-COAST PRESS in the U. S. Air Force heavy press program is in final assembly stage at the Harvey Aluminum plant in Torrance, Calif. The 8000-ton capacity unit will extrude one-piece aluminum airframe shapes. It is 288 ft long, 20 ft high, 21 ft wide and weighs 2000 tons. A larger press in the same plant will have 12,000-ton capacity.

Mechanisms Conference Will Report European Developments

Similar Meetings In Germany To Be Noted

An interesting feature of the Third Mechanisms Conference to be held at Purdue University this May will be an informal report by Professor Richard S. Hartenberg on European mechanism development. Professor Hartenberg attended the European equivalent of the Mechanisms Conference in Bingen am Rhein, Germany, last fall, and presented a paper there. His comments will afford a comparison—personal and technical—of mechanism affairs here and abroad.

Professor Hartenberg will give one of the scheduled talks at the conference. Other subjects covered by the program include mechanism synthesis, mechanisms for inter-

---

Front Cover

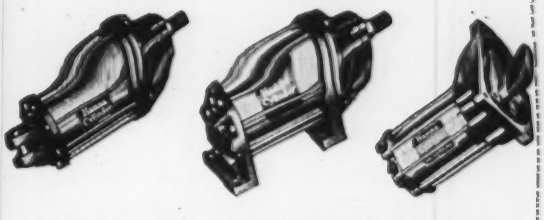
With the warm winds of spring gently wafting their wayward way through our art department, it's only natural that our cover, by George Farnsworth, should feature springs. Despite the bouncy nature of the weather, however, the cover theme is actually keyed into the article, "Helical Compression Springs," by Edwin F. Smith.

FOR DEPENDABLE POWER AND CONTROL

Choose The Finest

Hanna LP

AIR & HYDRAULIC CYLINDERS

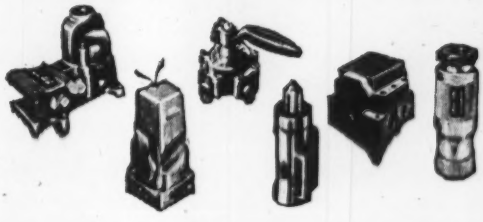


For low pressure air and hydraulic operation. Thousands of varied applications have proved the quality and reliability of these Hanna cylinders. Bore sizes range from 4" to 14". These cylinders, combined with Hanna T750 Series cylinders, offer a complete range of cylinder sizes and mounting styles. Made in any practical stroke length.

WRITE FOR CATALOG 236B

Hanna

AIR AND HYDRAULIC VALVES



Designed to provide most efficient control for Hanna cylinders — ideal for other fine control jobs too. Many types available for hand, foot and electric operation, speed control, pilots and master for automatic and remote control.

Write for Catalog 254

Hanna Filters, Lubricators, Regulators, Traps

These accessories provide complete protection for precision-built cylinders and valves—will keep maintenance costs at a minimum.

Write for Catalog 105

Hanna Engineering Works

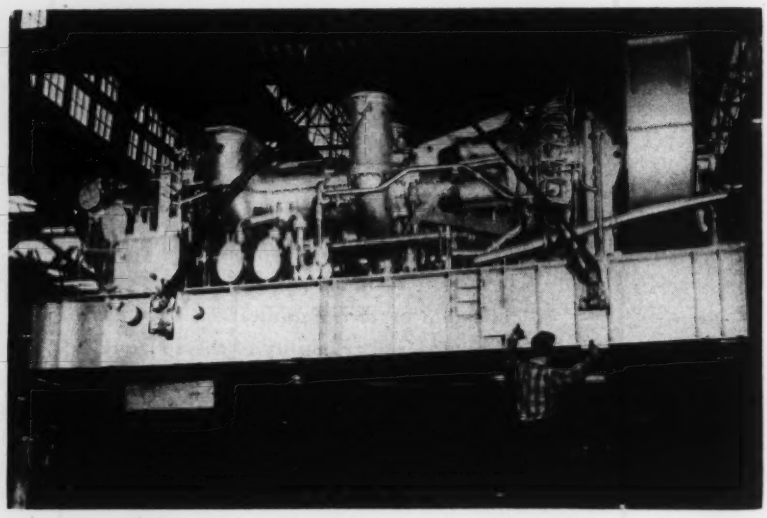
1751 Elston Avenue • Chicago 22, Illinois

HYDRAULIC AND PNEUMATIC EQUIPMENT . . . CYLINDERS . . . VALVES . . . RIVETERS

mittent motion, and cam design.

Following the scheduled talks, a series of discussion groups are being planned to give designers the opportunity to discuss informally the problems in their own fields or industries.

Dates of the Third Mechanisms Conference are Thursday and Friday, May 24 and 25. Refer to page 226 for further details on registration and program.



MORE POWER IN SMALLER PACKAGES for cargo vessels will be supplied by combustion gas turbines like this G-E 6600-hp model. The turbine was shipped recently to Newport News, Va., to be installed in the Liberty ship *John Sergeant.* Following sea trials with the compact power plant, the freighter will operate in trans-Atlantic service. Gas turbine power for Liberty ships is part of the U. S. Maritime Administration's program to improve the mobilization potential of the nation's defense reserve fleet.

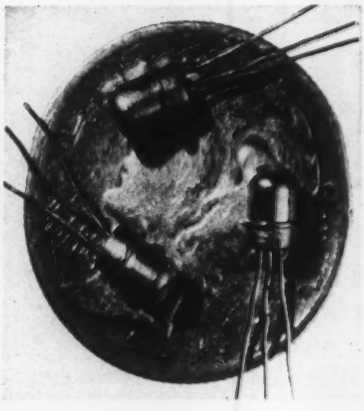
New Transistor Is Tiniest Yet

PHILADELPHIA, PA.—A subminiature transistor, believed to be the smallest yet developed, has been announced by Philco Corp.

The new transistor is designated M-1. It is enclosed by a metal can hermetically sealed by welding to give protection from moisture and contaminants. It can withstand acceleration of 20,000 *g* and operates on as little as 0.0001-watt.

The M-1 is a junction-type three-layer transistor. Its basic component is a germanium wafer the size of a pinhead. Leads are soldered to a dot of indium on each face of the wafer.

Philco used the new transistor in a miniature amplifier, made for demonstration purposes, the size of a pencil eraser. The amplifier has a 70-decibel gain or a power gain of 10 million. It employs a new type of direct coupling circuitry developed principally for electronic computers.



New Mill Housings Are Largest U.S. Castings

PITTSBURGH, PA.—Two rolling-mill housings believed to be the largest castings made in this country have been produced by United Engineer-

Topics

Russian jet airliner, recently announced, is capable of carrying up to 20 passengers at about 500 mph. Powered by two jet engines, the plane cruises at nearly 33,000 ft. All of its equipment, including instruments, was made in Russia.

• • •

RCA advanced development laboratory for development work on ferrites is being planned. It will be located in Needham, Mass.

• • •

Superfast camera that takes 15 million photos a second has been announced by Eastman Kodak. Rotating mirrors are used to achieve the high speed. Jet engine combustion is one of the subjects to be studied with the device.

• • •

Atomichron is the name of a frequency standard based on the resonant frequency of a cesium atom. It is said to be accurate to 1 part in 10 billion.

• • •

Science Scouts, a group of Boy Scouts interested in engineering careers, have been organized by a group of West Coast engineers. They hope to become an official part of the Boy Scouts of America.

• • •

Gas-turbine Plymouth is being road tested on a 3000-mile trip. Endurance of the power plant is to be determined in this cross-country jaunt.

• • •

Musical telephone will soon replace the jangling bell, according to Bell Labs. We'll bet it won't sound any sweeter when the called party is taking a shower.

• • •

New two-pin miniature lamp has made its appearance. Conventional screw-in or bayonet base has been replaced by two small pins. Mounting space is greatly reduced, making the unit easier to fit into tight spots.

• • •

National standards for commercial and industrial use of fissionable material are being formulated by a committee of the ASA.

• • •

Transistor auto radios will soon begin to appear in some of the new models.

Facing Page—ITEM 558→

Unitool*. . . *a fast, easy, low-cost way* to produce prototype bevel gears!

Now you can produce small quantities of spiral bevel, Zerol® bevel and hypoid gears with a comparatively small capital outlay and without specially trained personnel.

You can reduce the time and expense it takes to change your angular drive from a drawing board idea to a working model, too, because the Unitool Method produces good quality gears directly from the initial calculations.

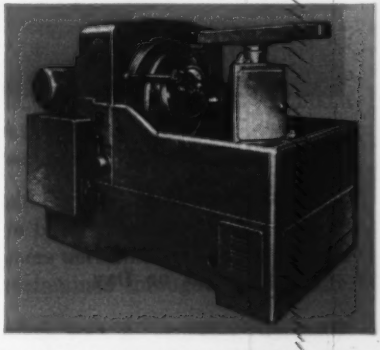
The Unitool Method is based on a fundamentally different theoretical approach to bevel gear generation. Only six different cutters are required to cut gears up to 14" pitch diameter—spiral bevel and Zerol bevel pairs of any ratio; hypoid pairs 3:1 ratio and higher. Because these cutters have a wide overlap in range, cutter diameter is not critical.

Calculations are short enough and easy enough for you to do in your own plant. Correct tooth thickness and position of contact are easily determined without requiring special operator training.

The Unitool Method is designed especially for the Gleason No. 106 and No. 116 Hypoid Generators which feature increased universal cutter tilt.

*Trademark

We will be glad to send further information on the Unitool Method and the two Gleason Generators best suited for it at your request.



The Gleason No. 106 Hypoid Generator is a high-speed machine for spiral bevel, Zerol bevel and hypoid gears up to 8½" pitch diameter. Its larger counterpart, the No. 116 Hypoid Generator, handles the same type gears up to 18" pitch diameter.

GLEASON WORKS

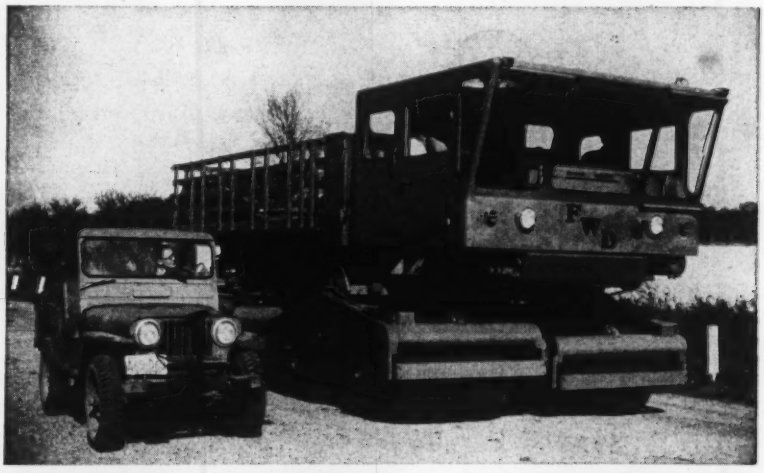
Builders of bevel gear machinery for over 90 years

1000 UNIVERSITY AVE., ROCHESTER 3, N. Y.

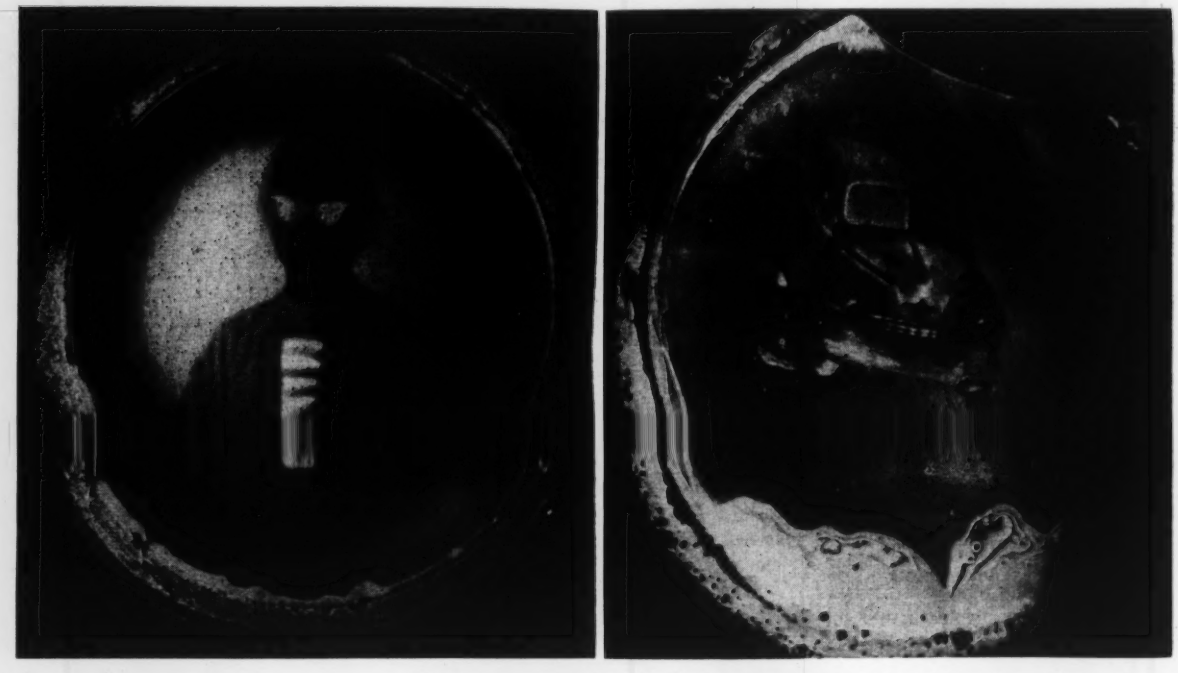
ing and Foundry Co. Each housing has a finished weight of 400,000 lb.

Molds for the castings were set in a pit which measured 86 by 32 by 18 ft deep. For each housing, five open hearth furnaces were tapped into five ladles which were then poured simultaneously. Three weeks were allowed for cooling before removing the castings from the molds.

New solvent cement for joining polyvinyl chloride pipe fittings and flanges has been developed by Tube Turn Plastics Inc. It can be applied with a paint brush and is claimed to bridge a greater diameter gap than similar bonding agents. A cemented joint can be handled in an hour and reaches working strength in 48 hours.



ROCK AND ROLL TRUCK is the "Terracruzer" developed for the armed forces by Four Wheel Drive Auto Co., Clintonville, Wis. The vehicle is 12 ft wide, 25 ft long, 10 ft high, and the first to use Goodyear "Rolligon" tires. The tires are rubber bags, each 3½ ft in diameter, 5 ft long, and each driven by rollers which engage the tire tread. At pressures of 3 to 5 psi, tires give smooth ride over rough or soft ground, eliminate conventional truck springs. The Terracruzer has an 8-cylinder engine, air-cooled.



Temperature sensitivity of the evaporograph is evident from these photographs of a girl holding a glas of ice water and an automobile whose tires and radiator were still hot when the picture was taken.

Color Pictures Made Of Objects in Dark

Device Uses Radiation, Works Night or Day

CAMBRIDGE, MASS.—A new instrument with which a man can see in the dark has been shown to the public recently by Baird Associates Inc. The device is called an evaporograph, nicknamed EVA. It can spot a man 200 yd away or a house a mile distant in total darkness. It does not use electronic circuitry.

EVA was designed originally for the armed services. It employs the principle that different materials radiate varying intensities of infrared, depending upon temperature and surface. Radiation emitted from an object is focused as an image onto an oil film. The oil evaporates from minute areas at rates varying with the amount of radiation received. In reflected light, these differences in oil film thickness appear as different colors, like oil films on water.

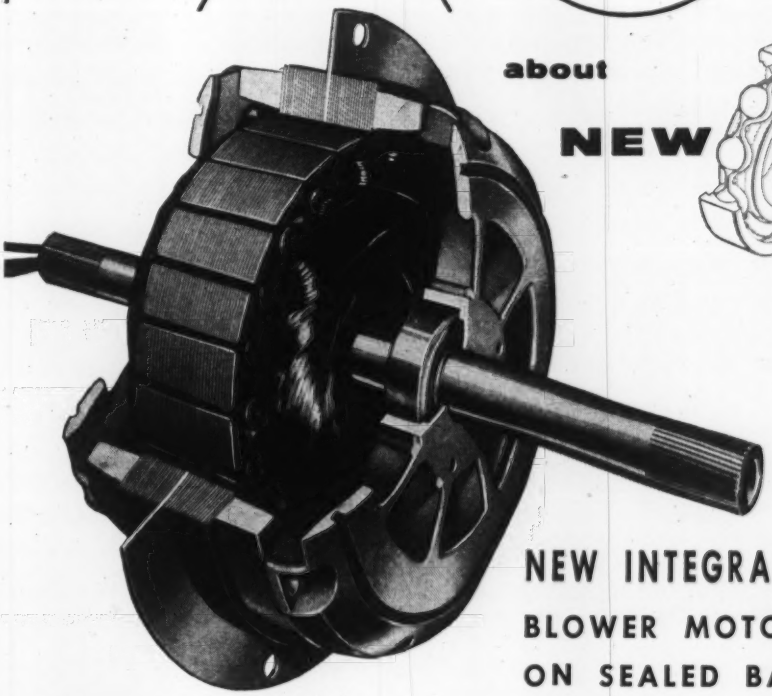
A thermal picture of the field of view is thus obtained in color. The picture can be viewed directly

FACTS

about

NEW DEPARTURE

BALL BEARINGS



NEW INTEGRAL-DRIVE BLOWER MOTOR DEPENDS ON SEALED BALL BEARINGS!

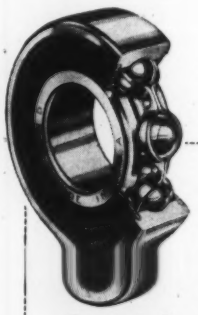
Nowhere is the superiority of New Departure sealed ball bearings in electric motor applications better exemplified than in this new integral-drive blower motor.

Revolutionary "inside-out" design of this new motor imposed a lubrication problem solved by the permanent-lubrication characteristic of the finest sealed ball bearings. In this motor, the rotating element, to which the blower wheel is attached, is on the outside and revolves around a stationary shaft through which the lead wires pass. "Sealed and lubricated-for-life" New Departure ball bearings were selected because they assure permanent lubrication, regardless of centrifugal force. Also, because motor and blower wheel share the same permanently lubricated bearings, this integral unit is free of the need for periodic servicing.

Equally important, New Departure sealed ball bearings handle combination loads in any position . . . assure positive alignment of rotor and stator. This means a versatility of application for this motor that offers new freedom to designers.

Sealed ball bearings also help increase motor efficiency and reduce electrical hum. Since in ball bearings wear is so slight as to be entirely negligible, designers were able to build in a smaller precision air gap, which is maintained throughout motor life.

Let New Departure's unexcelled engineering service show you the many advantages of sealed ball bearings in electric motor and other applications.

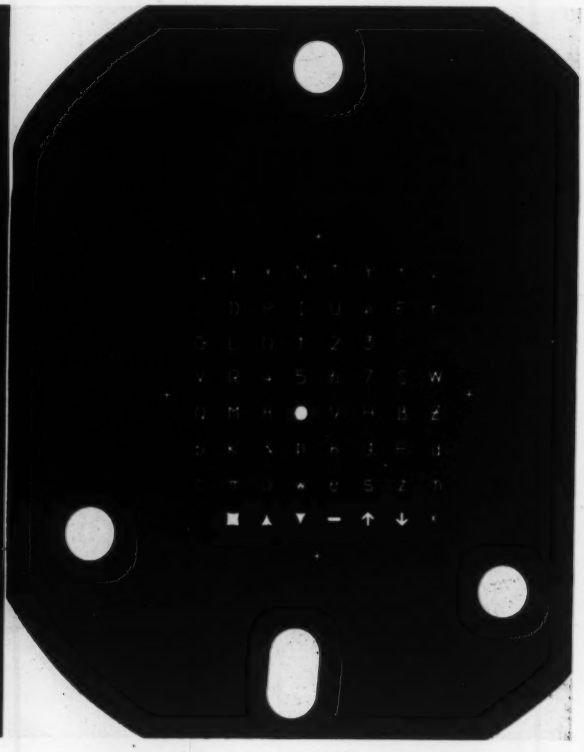


5 advantages of New Departure's Sentri-Seal ball bearings in electric motor applications

- **SEALED AND LUBRICATED FOR LIFE!** No need for relubrication; no danger of over- or under-lubrication.
- **SIMPLIFY DESIGN!** Eliminate need for separate seals and grease fittings.
- **CARRY LOADS IN ANY POSITION!** Moving parts are held in positive alignment, regardless of motor mounting position.
- **WEAR IS NEGLIGIBLE!** Require no attention for adjustment for wear. Have a reputation for outlasting the products they serve.
- **QUIET-RUNNING!** New Departure ball bearings are precision-made, run smoothly. Their uniformity is a guarantee of dependability.

NEW DEPARTURE • DIVISION OF GENERAL MOTORS • BRISTOL, CONN.

—ITEM 559—



FINE PRINT FOR THE ELECTRONICS INDUSTRY is this representative pattern of characters. Numbers and letters are 0.012-in. high, produced in nickel film 0.0001 in. thick. The W. & L. F. Gurley Co. electroformed the characters by nickel plating on a beryllium copper base. After the image is formed in the nickel, the base is removed by electroetching. Hughes Aircraft will use the pattern in the electron gun of their typotron tube.

or photographed. The unit is said to observe radiation differences corresponding to temperature variations of one to several thousand degrees F.

New Laminates Speed Printed Circuit Making

Copper-Clad Phenolics Have Improved Hot-Solder Resistance

PHILADELPHIA, PA.—Only a short time is required for dip soldering in the production of printed circuits with a new line of copper-clad phenolic laminates. The laminates have dip-solder temperature resistance of 500 F for over 30 seconds. An adhesive applied to the bonding surface provides this heat resistance and also effects a bond strength of 12 to 15 lb per inch of width.

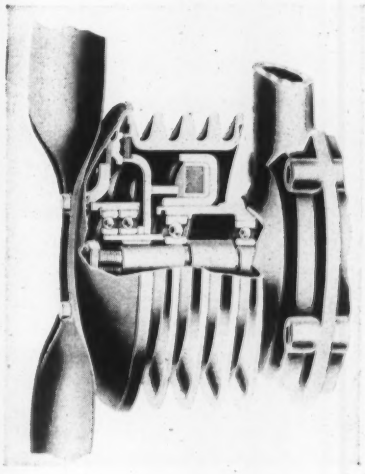
High soldering temperatures not only speed the soldering operation, but also aid in making perfect connections with minimum bridging.

Six grades of copper-clad laminates are available, bonded on one or both sides with either rolled or electrolytic foil. Foil thicknesses currently available are 0.00135 and 0.0027-in. The laminates are made by National Vulcanized Fibre Co. by a process developed by Houghton Laboratories Inc.

Clutch Unit Eliminates Unnecessary Fan Operation

BELOIT, WIS. — A low-cost fan clutch unit, claimed easy to install on internal combustion engines, has been introduced by Warner Electric Brake & Clutch Co. Controlled by a thermostatic switch, the clutch disengages the fan when outside temperatures make fan cooling unnecessary.

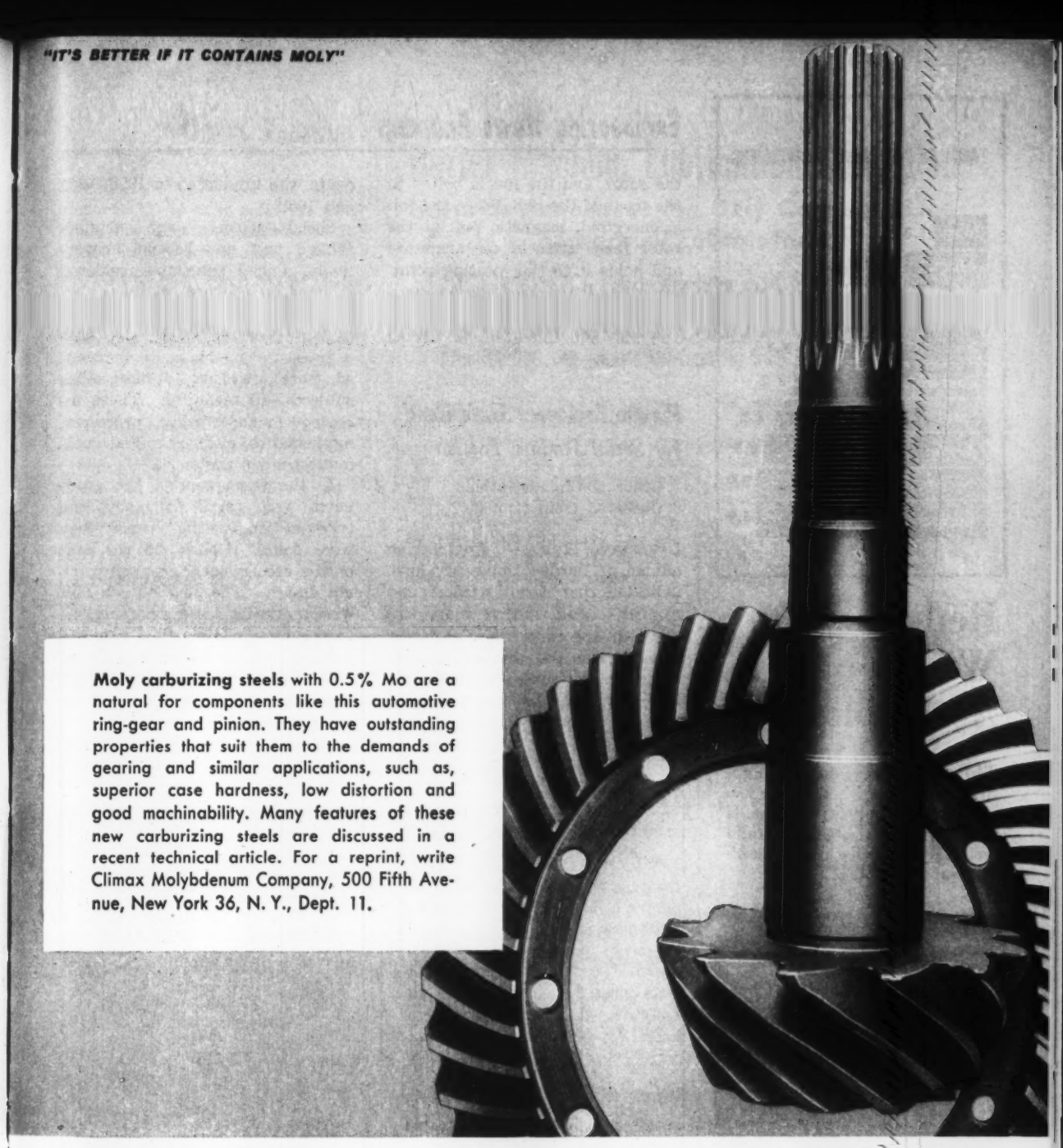
Tests of the fan clutch installed on an automobile engine showed that the fan is not needed when outside temperatures are below 50 F. When the temperature is over 90 F and the automobile is traveling at 40 mph, the fan engages about 40 per cent of the time. An estimated 8 to 12 hp is required to drive the fan on an automobile engine.



The application illustrated utilizes a clutch of stationary-field design. The field is mounted on the water pump housing. The sheave and rotor are fastened together and mounted to drive the shaft continuously, so the water pump impeller rotates constantly. A hub is mounted on bearings in front of

Facing Page—ITEM 560→

"IT'S BETTER IF IT CONTAINS MOLY"



Moly carburizing steels with 0.5% Mo are a natural for components like this automotive ring-gear and pinion. They have outstanding properties that suit them to the demands of gearing and similar applications, such as, superior case hardness, low distortion and good machinability. Many features of these new carburizing steels are discussed in a recent technical article. For a reprint, write Climax Molybdenum Company, 500 Fifth Avenue, New York 36, N. Y., Dept. 11.

Molybdenum Carburizing Steels

MOLYBDENUM OFFERS THE ECONOMICAL KEY TO PERFORMANCE

Over the years, molybdenum carburizing steels have proved their merits in scores of applications and at every level of production.

Design engineers know moly steels for their uniform hardenability, toughness and wear resistance.

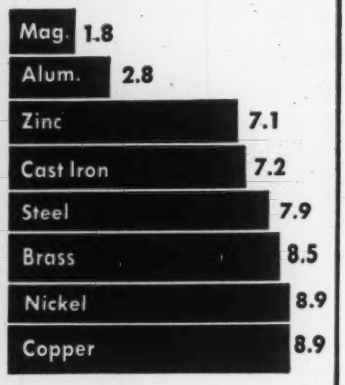
Production men know that moly steels are easy to heat treat, easy to machine.

Management knows that moly steels mean economy in fabrication, high performance in a wide range of end products.

Standard molybdenum carburizing steels are widely available. Higher moly analyses may be ordered in heat lots from a number of leading suppliers.

CLIMAX MOLYBDENUM

TABLE OF COMPARATIVE WEIGHTS
(Specific Gravities)



Reducing the Weight of Assemblies?

This teleprinter cover, deep-drawn from .065" thick magnesium, weighs only 3 lbs. 13 oz. If it were made of steel, it would weigh almost 18 lbs.; or of aluminum, about 5¾ lbs.

In a wide range of products such as housings and covers, direct gauge-for-gauge substitution is often possible.

Magnesium gives you lightness plus excellent drawability.

B&P engineers will help you redesign in magnesium. B&P offers the magnesium industry's most complete facilities for fabrication and assembly. Your inquiry will bring a descriptive booklet.

BROOKS & PERKINS, INC.

1940 West Fort Street
Detroit 16, Michigan

—ITEM 561—

the rotor, and the fan is bolted to the front of the hub. When the coil is energized, magnetic pull at the rotor faces attracts the armature and holds it to the rotating rotor. The hub and fan are then driven with the pulley.

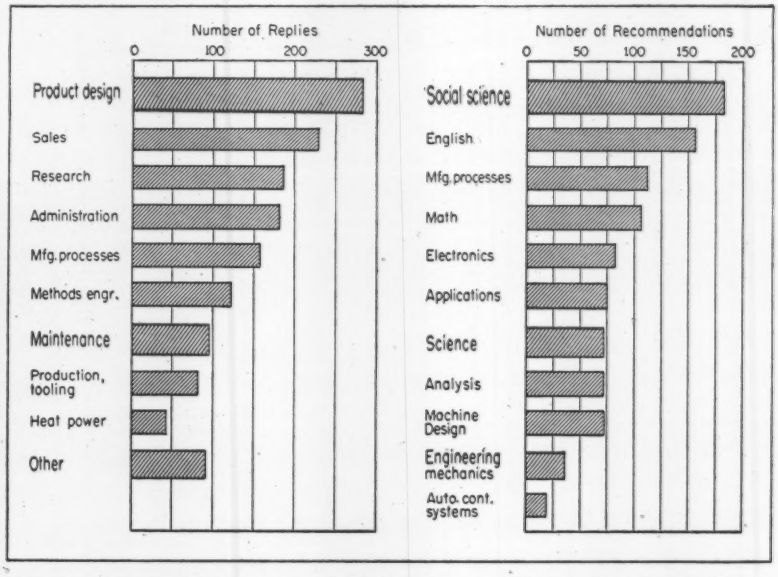
Purdue Engineers State Need For Social Studies, English

Other Recommendations Observed from Canvass

LAFAYETTE, IND. — Engineering alumni of Purdue University have indicated that social sciences and English should receive more emphasis in the curriculums for their fields. This is one observation from a recent survey conducted by Professor O. D. Lascoe of mechanical and electrical engineering students who graduated in 1950, 1951 and 1952.

Social sciences and English ranked first and second, respectively, among subjects considered to merit more emphasis. In lesser degrees, the graduates recommended more attention to nine other subjects, all technical. These included manufacturing processes, mathematics, electronics and automatic control systems.

In the same survey, the graduates were asked to report the type of engineering work they were doing. Nearly 20 per cent of the returns were marked product design. The next 40 per cent were marked sales engineering, research or administration. Only 6 per cent of the returns indicated fields of employment other than nine engineering groups listed on the questionnaire.



Graph at the left shows types of engineering work being done by 1950-1952 mechanical and electrical enginering graduates of Purdue University. At the right is a list of subjects which should receive greater emphasis in engineering curriculums, according to recommendations of these alumni.

"Quick-Fix" Process Gives Aluminum No-Smear Coat

LOS ANGELES, CALIF.—Development of a process that provides a surface conversion coating for aluminum has been announced by Turco Products, Inc. Turco says the process affords protection from corrosion, and improves paint adhesion and appearance. The process is called Turcoat 4178 and meets Government specification MIL-C-5541.

Chief advantage of the new process is said to be the "quick fix" offered by the Turcoat materials. The coating becomes fixed and nonsmearing immediately upon application.

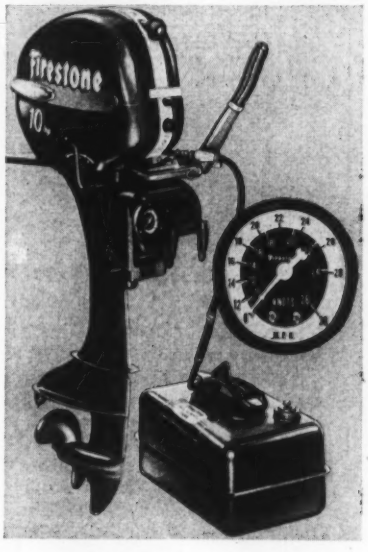
The coating is the surface-conversion type, partially derived from the metal surface itself and,

therefore, integral with the metal surface. It is acid resistant and offers low electrical resistance. It is not brittle; coated metal can be bent or formed after the coating is applied. The coating can be applied by immersion, spray wash or conventional hand methods. Color of the coat is light yellow.

In the control of the Turcoat process, pH is claimed the only critical point. Standard temperatures and concentrations are observed, but are not critical.

Fast Outboards Now Clock Their Own Speed

AKRON, O. — The first outboard motors equipped with speedometers are being introduced this year by Firestone. A "knotometer" is standard equipment on three new



models. It measures speed in both knots and miles per hour.

Operating independently of the engine, the knotometer registers speed according to the resistance of water encountered by the boat.

Airborne television is being developed as an aid in directing military operations. In a system built by Admiral Corp. for the U. S. Army Signal Corps, a plane carrying a camera and transmitter at approximately 1000 ft would have a line-of-sight transmission range

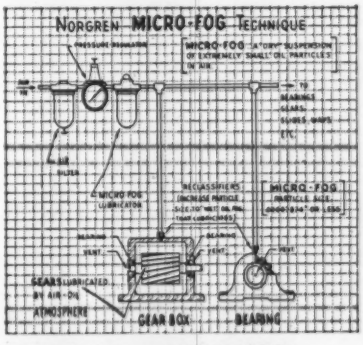
(Continued on Page 22)

Better Machine Lubrication Simplified

Norgren Announces the Only Complete Line of Aerosol Lubricators

. . . Now, MICRO-FOG Lubricators are available for 32, 200, 300, and 1000 Bearing Inch Requirements

The Norgren MICO-FOG principle has made practical the application of oil-fog lubrication to large machine tools, lubricating bearings, gears, chains, and other machine parts which always before have been lubricated by splash systems, force feed systems and other methods. Today, Norgren MICRO-FOG Lubricators are providing lubrication for large and small machines in many types of industry.

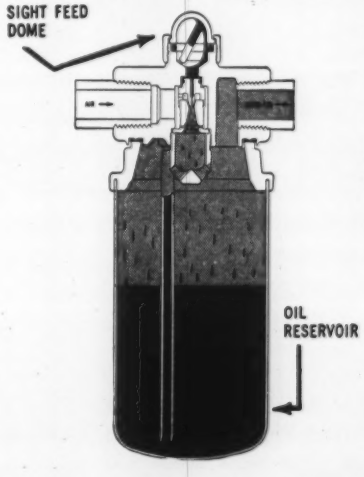


What is Norgren MICRO-FOG?

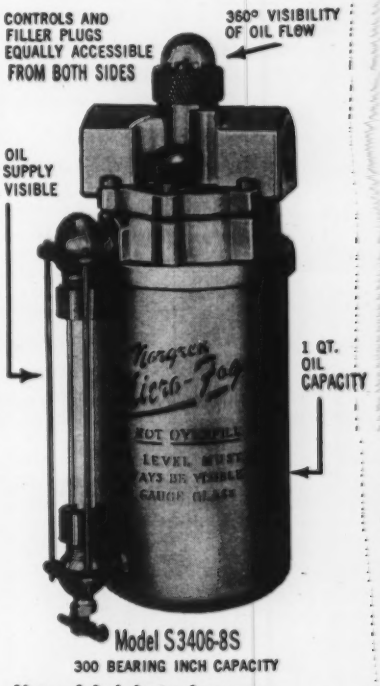
Norgren MICRO-FOG is an air-borne suspension of extremely small oil particles (.00007874" or less in diameter). Because the oil particles are so small, they can be conveyed long distances through complex piping systems without reclassifying and flooding the lines with oil — a condition heretofore not possible with conventional oil-fog systems.

How is Norgren MICRO-FOG formed?

Air passing through the venturi section of a Norgren MICRO-FOG Lubricator creates a pressure differential that draws oil from the reservoir. The oil is allowed to flow at a controlled rate into the venturi section.



The venturi creates an oil fog, discharging it into the upper regions of the oil reservoir. The heavier particles of oil return to the oil supply. Only the finer particles of 2 microns (.00007874") or less are carried into the air line.


CONTROLS AND FILLER PLUGS EQUALLY ACCESSIBLE FROM BOTH SIDES
360° VISIBILITY OF OIL FLOW
OIL SUPPLY VISIBLE
1 QT. OIL CAPACITY
Norgren Micro-Fog

Model S3406-8S
300 BEARING INCH CAPACITY

Now—A Lubricator for every requirement

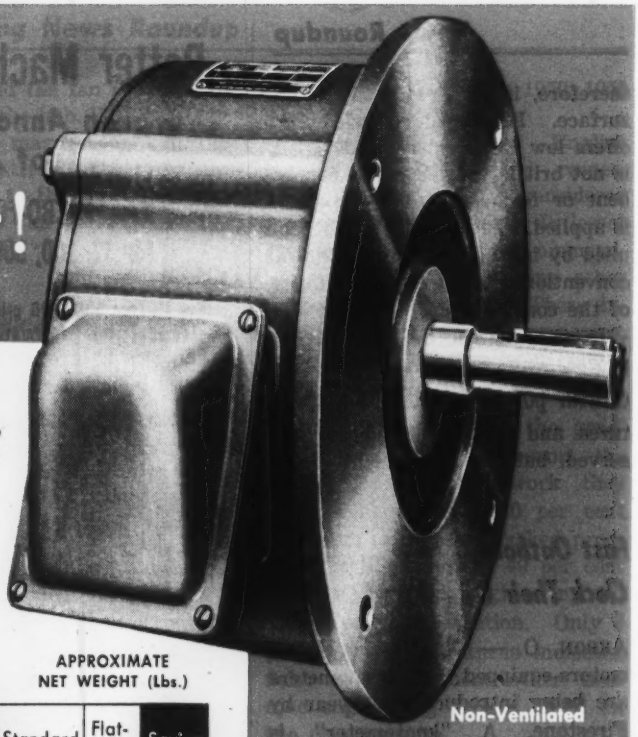
New models of MICRO-FOG Lubricators, having 200 and 300 bearing inch capacities, are now being manufactured by Norgren. These are in addition to the 32 and 1000 bearing inch capacity lubricators already in the Norgren line. The range of bearing inch capacities given by these models means that you can select a lubricator that will provide the most efficient lubrication for the job.

For complete information about Norgren MICRO-FOG Lubriation, call your nearby Norgren Representative listed in your telephone directory — or WRITE FOR NEW No. 700 CATALOG.

C. A. Norgren Co.
3442 So. Elati, Englewood, Colo.

—ITEM 562—

The Motor you asked for!



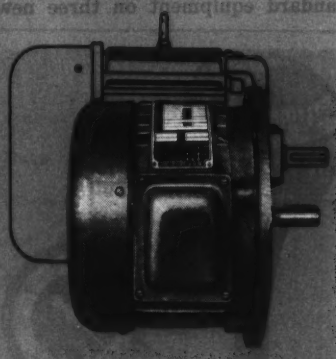
TAKES less space . . . because it's the new FLAT-Type Motor

GIVES more service . . . because it's a DIEHL

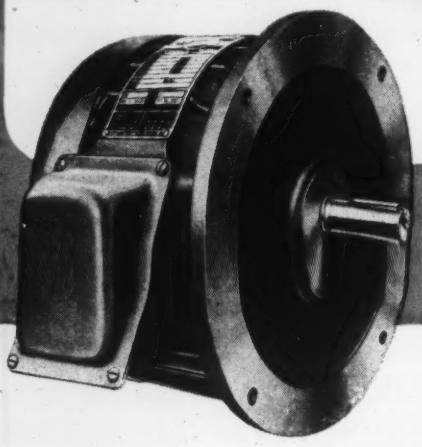
FOR SIZE AND WEIGHT, COMPARE THE NEW FLAT-TYPE WITH STANDARD MOTORS

FRAME SIZE		OVERALL LENGTH (Inches)			APPROXIMATE NET WEIGHT (Lbs.)		
Standard	Flat-Type	Standard	Flat-Type	Saving	Standard	Flat-Type	Saving
DIF 182	DIF 180	14 1/16	10 3/4	3 5/16	82	59	23
DIF 213	DIF 220	17 3/16	11 9/16	5 5/8	128	83	45
DIF 284U	DIF 280	26	13 13/16	12 3/16	272	135	137

Non-Ventilated



New Flat-Type superimposed on standard motor



Fan Cooled

The unique and perfect answer in *integral motors*—designed especially for the machine tool and equipment industries. Packs full horsepower in less space . . . actually up to 48% shorter than standard motors without sacrifice in performance. Many pounds lighter, too, than conventional motors (over 50% in some cases), meaning vastly reduced over-hung weight. Standard radial construction, easy to disassemble and reassemble . . . no precision alignments or complicated air-gap adjustments to contend with. Totally-enclosed . . . no dirt, dust or moisture can get in. Available (non-ventilated) in ratings to 3 H.P., and (fan-cooled) in ratings to 20 H.P.

Perhaps the Diehl Flat-Type Motor is just what you need to solve your application problems. Give us the details and we'll be glad to submit recommendations. Ask for your copy of Bulletin MD-3461.

Diehl

DIEHL MANUFACTURING COMPANY

Electrical Division of THE SINGER MANUFACTURING COMPANY

Finderne Plant, SOMERVILLE, NEW JERSEY

ATLANTA · BALTIMORE · CHARLOTTE, N. C. · CHICAGO · CINCINNATI · DETROIT · MILWAUKEE · NEEDHAM, MASS. · NEW YORK · PHILADELPHIA · PITTSBURGH

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For More Information Circle Item Number on Yellow Card—page 19

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USE A YELLOW CARD *for More Information . . .*

CIRCLE ITEM NUMBERS—Throughout the magazine, each advertisement carries an Item Number for use in requesting further information. All product descriptions, announcements and Helpful Literature items are also numbered, and for greater convenience are indexed below by Item Numbers.

EDITORIAL CLIPSHEETS—So you won't have to "clip" this issue, we'll be glad to send a personal copy of any article as long as the supply lasts. Just fill in the page number and title of article in the place provided on the Yellow Card.

Index to New Parts & Helpful Literature

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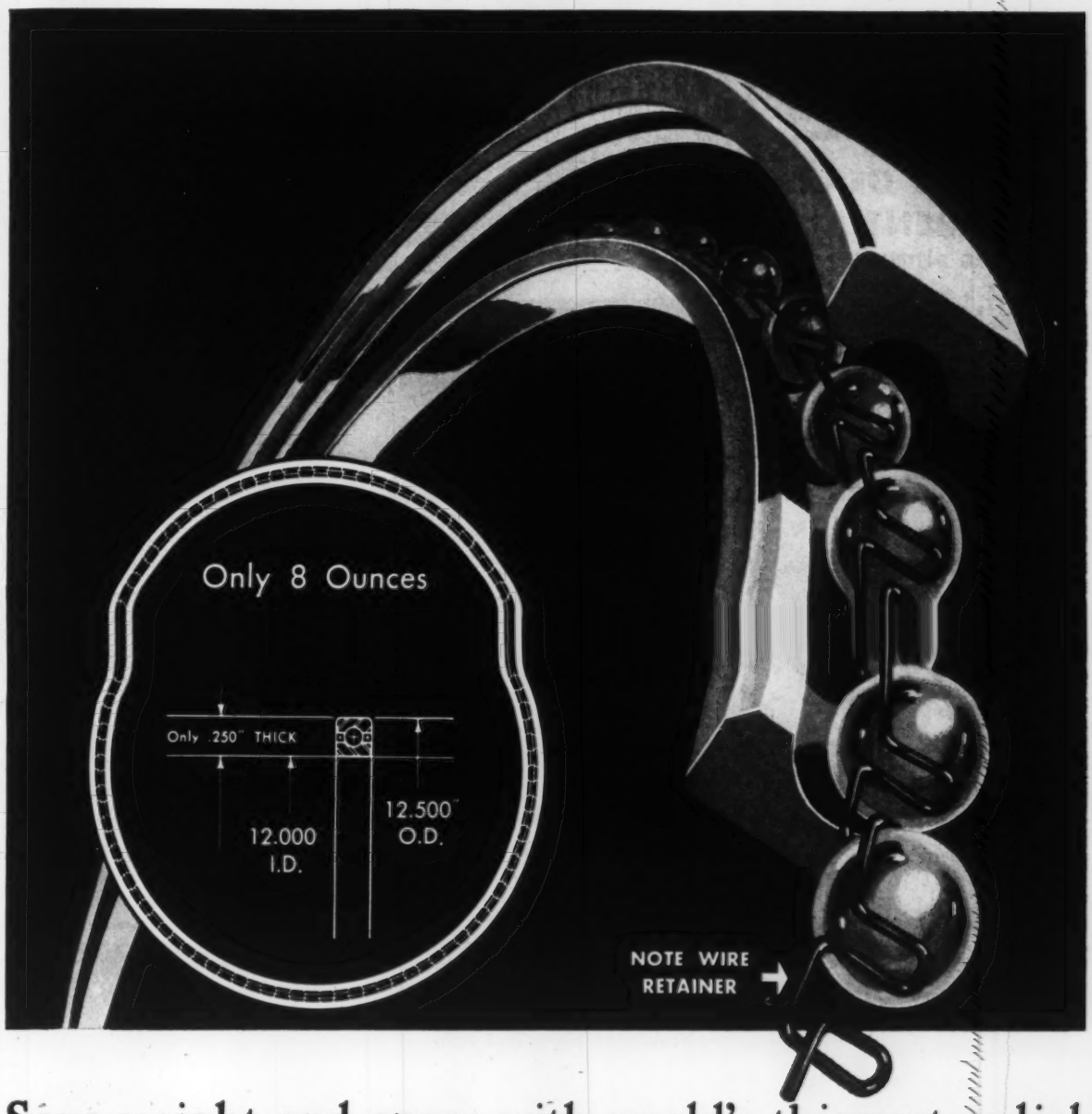


Save weight and space with world's thinnest radial ball bearings—*Reali-Slim* by Kaydon

HERE it is! A *Reali-Slim* radial ball bearing with a wire separator that has just short of a full complement of balls for maximum capacity. What's more, you still get all the advantages of a separator between the balls. This design also gives you a bearing that's light-in-weight and is, without a question, the thinnest bearing ever built in this diameter.

Whatever your product design, there's a small or large diameter *Reali-Slim* bearing that can be the right answer to your thin-section bearing problems.

The radial ball bearing, illustrated here, is *really slim* — 12.000" I.D., 12.500" O.D., .250" thick . . . *and weighs only eight ounces.* It has 9,810 lbs. static load capacity, 1,256 lbs. at 100 rpm. Kaydon is able to produce *Reali-Slim,* high-precision bearings because Kaydon specializes in the unusual.

Kaydon bearing engineers are prepared to give you valuable help with technical, thin-section bearing problems.

For detailed information on Kaydon's *Reali-Slim* line, ask for engineering catalog No. 54-RS3 detailing:

Reali-Slim Ball Bearings — Conrad, angular contact and 4-point contact types in seven standard cross sections from ¼" to 1.000" and in bore diameters from 4" to 40".

Reali-Slim Roller Bearings — Radial and taper roller types in cross sections from 9/16" and in bore diameters from 5" to 40".

THE KAYDON ENGINEERING CORP.

MUSKEGON • MICHIGAN

K-561

All types of ball and roller bearings — 4" bore to 120" outside diameter . . .

Taper Roller • Roller Thrust • Roller Radial • Bi-Angular Roller • Spherical Roller • Ball Radial • Ball Thrust Bearings

SINGLE
SPIDER GEAR DIFFERENTIALS
by FORD INSTRUMENT are
7 ways superior

AVAILABLE IN
four sizes: 1/8", 3/16", 1/4", and 5/16" shaft diameters
FOR EARLY DELIVERY

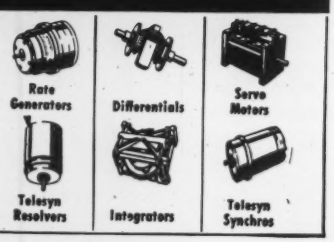
Ford Instrument's single spider gear differentials are engineered to highest military and commercial standards . . . to provide *extreme accuracy* in addition and subtraction, and in servo loop applications.

1—High sensitivity.
2—Minimum lost motion.
3—Precision Zerol gears.
4—Corrosion- and wear-resistant materials throughout.
5—Minimum working diameters for compactness.
6—Minimum weights.
7—Rugged, long-life design.

FREE a fully illustrated data bulletin gives performance curves and characteristics. Please address Dept. MD.

FORD INSTRUMENT COMPANY 43A
Division of Sperry Rand Corporation
31-10 Thomson Ave.
Long Island City 1, N. Y.

Ford Instrument's standard components

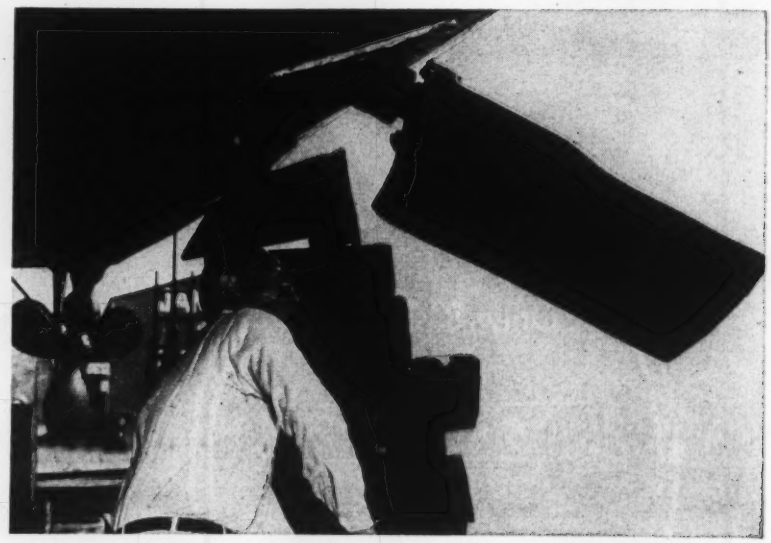


—ITEM 565—

(*Continued from Paye* 15)

of about 25 or 30 miles. With the aid of a panel of screens, each showing an aerial view of a different sector, a battle commander could have an immediate overall picture of enemy forces and their location.

The video signal would be carried by frequency modulation, in contrast to AM transmission used in commercial television.



One of the hydrofoil type fins that are part of the Gyrofin stabilizing system. It is installed on the *Wanderer*, a former submarine chaser which now serves as a floating research laboratory for the Sperry Gyroscope Co.

Ship Sprouts Fins To Control Roll

Stabilizers Keep Test Ship On an Even Keel

NEW YORK, N. Y. — The first stabilizer fins to be installed on an American vessel recently proved to be capable of smoothing out a 17-degree roll almost instantly. Demonstration of Gyrofin stabilizer action on the Sperry Gyroscope Co. research ship *Wanderer* indicates that safer, more comfortable ocean travel is possible through application of the system.

Major components of the Sperry stabilizer system are two underwater fins that project from opposite sides of the ship near its center and a control console located on the bridge. Gyroscopic instruments measure rate, angle and acceleration of roll, transmitting signals to hydraulic actuators that tilt the fins up or down to counteract roll. Principle of operation is similar to that of ailerons on an airplane.

Each fin can exert 3000 ton-ft of lift within 2 seconds. Roll of a vessel in heavy seas can be reduced by 80 or 90 per cent, and rolling motion can be reduced to less than 2 degrees continually under average conditions.

Gyrofin stabilizers are in production for installation on two ships now being converted to 370-passenger vessels.

In-flight refueling transmitters with 50 times the capacity of earlier mass fuel flowmeters permit measurement of as much as 600,000 lb of fuel per hour. The new IFR transmitter was developed by General Electric Co. for the critical mass measurement of fuel being transferred from tanker planes to bombers and fighters on long-range operations. It is mount-

If you're part of the Farm Machinery Industry you should know about SHARON SPECIAL STEELS

SHARONSTEEL

Sharon is particularly active in the farm machinery steel market. They are prime producers of hot and cold, flat rolled special strip steels in large coils, cut lengths or sheets especially for farm machine manufacture.

If you want exactly the right steel for the job, why not call in the man with farm machine steel experience—your Sharon Steel Salesman.

Typical Sharon products used by leading farm machine manufacturers include:

GALVANITE* a superior hot dip zinc coated steel.

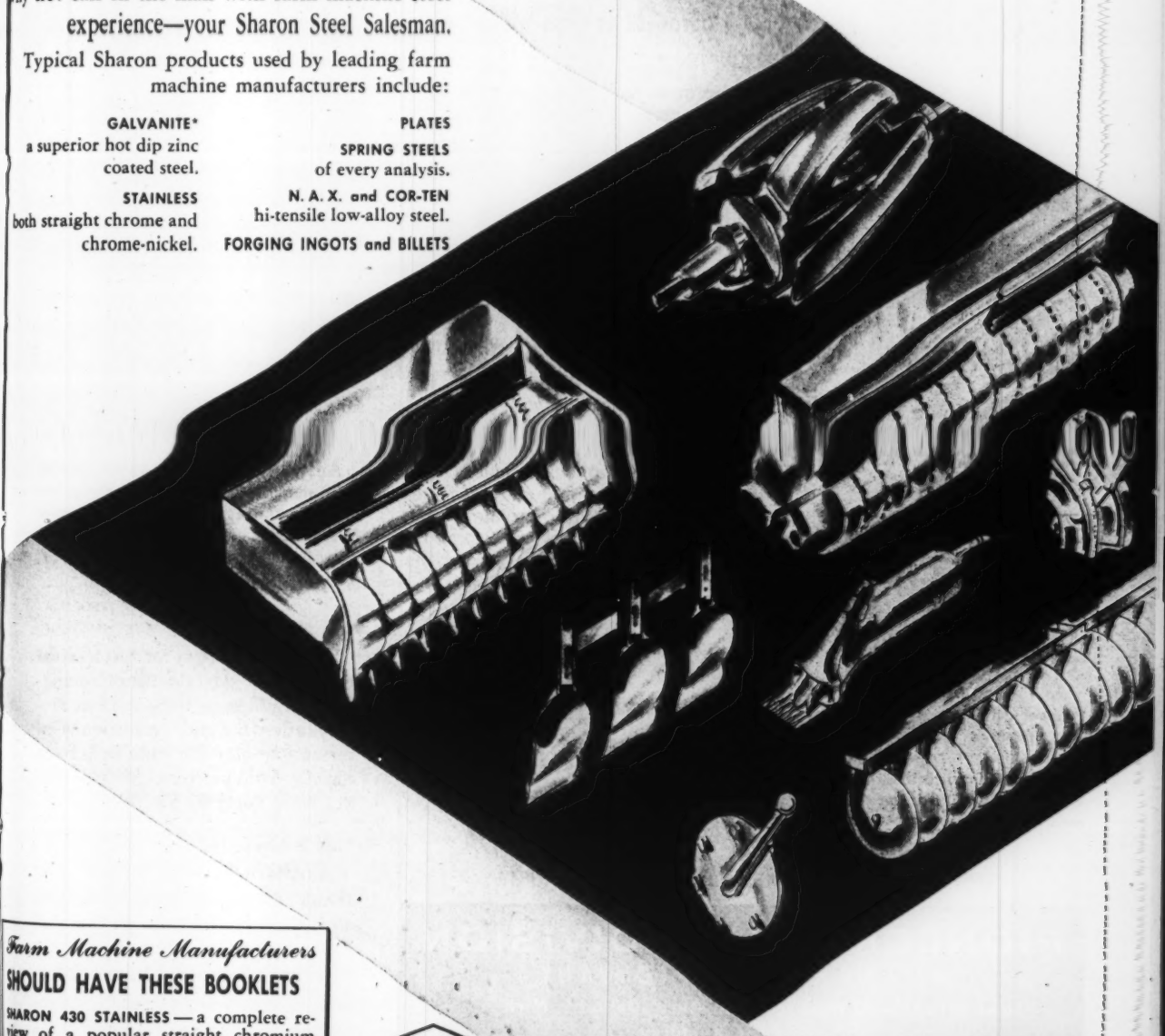
STAINLESS both straight chrome and chrome-nickel.

PLATES

SPRING STEELS of every analysis.

N. A. X. and COR-TEN hi-tensile low-alloy steel.

FORGING INGOTS and BILLETS



Farm Machine Manufacturers
SHOULD HAVE THESE BOOKLETS

SHARON 430 STAINLESS — a complete review of a popular straight chromium grade.

SHARON GALVANITE* — The story of one of the most popular hot dip zinc coated steels.

*Trademark registered by Sharon Steel Corporation

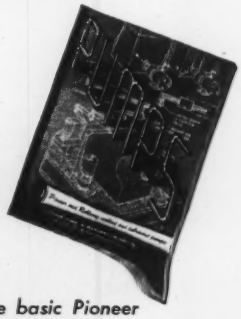
SHARON STEEL CORPORATION *Sharon, Pennsylvania*

District Sales Offices: Chicago, Cincinnati, Cleveland, Dayton, Detroit, Grand Rapids, Indianapolis, Los Angeles, Milwaukee, New York, Philadelphia, Rochester, San Francisco, Seattle, Montreal, Que., Toronto, Ont.

This New PIONEER Coolant Pump gives you Important Advantages

1. Totally enclosed motor, with extra-heavy shaft and heavy-duty ball bearings.
2. Handles abrasives or chips without injury to the pump.
3. Will pump down to 1⅛"; self-priming to 1" liquid level.
4. Permits clean-out of machine sump with minimum time and labor.
5. Interchangeable with any make pump with standard mounting dimensions.
6. Sealless design with no metal-to-metal moving parts.
7. Can be furnished with any desired electrical characteristics.
8. Three optional outlets: left external, right external, center outlet through mounting flange. The latter permits compact, clean-cut design of machine with no exposed piping.

Pioneer offers more than 400 models of impeller-type and positive displacement pumps to meet every coolant pump requirement; or we will develop designs for specific applications. Our application engineers will welcome the opportunity to discuss your pump requirements with you.



Send for our illustrated booklet covering the basic Pioneer designs in both impeller-type and positive displacement pumps.

PIONEER PUMP DIVISION
DETROIT HARVESTER COMPANY
Sales Office: 5450 West Jefferson Ave., Detroit 9, Michigan
Plant: Paris, Kentucky

—ITEM 567—
For More Information Circle Item Number on Yellow Card—page 19

ed in the fuel line leading to the boom which extends from the tanker plane during refueling. The instrument weighs only 17 lb and operates at pressures to 480 psi.

National Society of Professional Engineers has moved its headquarters to 2029 K St., NW, Washington 6, D. C.

Meetings

AND EXPOSITIONS

May 2-4—

American Institute of Electrical Engineers. North Eastern District Meeting to be held at the Sheraton Hotel, Rochester, N. Y. Additional information may be obtained from society headquarters, 33 W. 39th St., New York 18, N. Y.

May 3-9—

American Foundrymen's Society. Biennial Convention and Show to be held at Convention Hall, Atlantic City, N. J. Additional information may be obtained from society headquarters, Golf & Wolf Rds., Des Plaines, Ill.

May 6-9—

American Institute of Chemical Engineers. Spring Meeting to be held at the Roosevelt Hotel, New Orleans, La. F. J. Van Antwerpen, 120 E. 41st St., New York 17, N. Y., is secretary.

May 8-11—

American Society of Mechanical Engineers. Metals Engineering-AWS Conference to be held at Hotel Statler, Buffalo. Additional information may be obtained from society headquarters, 29 W. 39th St., New York, N. Y.

May 9-11—

American Welding Society. National Spring Technical Meeting and Welding Show to be held at Hotel Statler and Memorial Auditorium, Buffalo. Additional information may be obtained from society headquarters, 29 W. 39th St., New York, N. Y.

May 9-11—

Investment Casting Institute. Spring Meeting to be held at Hotel New Yorker, New York. Harry P. Dolan, 27 E. Monroe St., Chicago 3, Ill., is executive secretary.

May 14-17—

Design Engineering Show and Conference to be held at Convention Hall, Philadelphia. Additional information may be obtained from Clapp & Poliak, 341 Madison Ave., New York 17, N. Y.

May 16-18—

Anti-Friction Bearing Manufacturers Association. Annual Meeting to be held at Princeton Inn, Princeton, N. J. H. O. Smith, 60 E. 42nd St., New York 17, N. Y., is secretary.

May 16-18—

Society for Experimental Stress Analysis. Spring Meeting to be held at the William Penn Hotel, Pittsburgh, Pa. Dr. W. M. Murray, P. O. Box 168, Cambridge 38, Mass., is secretary-treasurer.

May 23-24—

American Iron & Steel Institute. Annual Meeting to be held at the Waldorf-Astoria, New York. George S. Rose, 350 Fifth Ave., New York 1, N. Y., is secretary.

May 23-25—

American Society of Mechanical Engineers — Engineering Institute of Canada. Meeting to be held at the Mount Royal Hotel, Montreal, Quebec, Canada. Additional information may be obtained from A.S.M.E. headquarters, 29 W. 39th St., New York, N. Y.

May 23-26—

National Society of Professional Engineers. Annual Meeting to be held at the Ambassador Hotel, Atlantic City, N. J. Additional information may be obtained from society headquarters, 2029 K St., NW, Washington 6, D. C.

May 24-25—

National Warm Air Heating & Air Conditioning Association. First Technical Conference to be held at the Edgewater Beach Hotel,

Townsend *Tuff-Tite*® Fastener Gives Leakproof Fastening... Protects Enamel On Washer Tub

A large manufacturer of domestic washing machines has found the solution to leakproof fastening of tub to frame with Townsend Tuff-Tite fasteners. Previously, a three-piece fastener had been used—bolt, metal washer and flat neoprene washer.

Now, the one-piece Tuff-Tite brass bolt and washer with the conical assembled neoprene washer shown above is doing the job.

The result—positive leakproof assembly—superior protection from chipping the porcelain enamel—greater resistance to loosening from vibration. Assembly has been speeded and triple inventory eliminated.

This achievement is made possible by the design of all Tuff-Tite fasteners. They have an undercut in the washer head which controls and traps the neoprene when the fastener is tightened. The neoprene is forced into the hole and around the threads to provide a cushion which protects the surface and forms a water-tight and air-tight seal.

Tuff-Tite fasteners are available with many types of screw and bolt shanks and head styles. They are made of carbon, alloy and stainless steel, aluminum, brass and other metals.

To learn more about how Tuff-Tite can give you leakproof surface protection with economy, use the coupon below.

Townsend
COMPANY • ESTABLISHED 1816

Sales Offices in Principal Cities

In Canada: *Parmenter & Bulloch Manufacturing Company, Ltd., Gananoque, Ontario*

TOWNSEND COMPANY
Post Office Box 237E
New Brighton, Pa.

Please send to me without obligation "Tuff-Tite" Bulletin TL-97.

Name_____ Title_____
Company_____
Street_____
City_____ Zone____ State____

CASE HISTORY 1

REQUIRED:
A dependable supply of this small, machined electrode to meet customer's quality and quantity needs at reduced cost.

HASSALL SOLUTION:
Hassall-designed re-heading process, involving no critical dimension changes, resulted in a 59% cost reduction to customer.

CASE HISTORY 106

REQUIRED:
Replacement for stud with insufficient head to act as stop for automatic hammering.

HASSALL SOLUTION:
Substitution of Hassall cold-headed collar stud with annular threads for greater holding power. Substantial cost savings.

CASE HISTORY 64

REQUIRED:
An economical method of manufacturing perforating punches out of hard materials such as drill rod.

HASSALL SOLUTION:
The Hassall cold-heading process plus engineering skill overcame the difficulties presented by these alloys at considerable savings.

CASE HISTORY 37

REQUIRED:
Bumper bolt with bonded rubber cap for license plate support.

HASSALL SOLUTION:
The large head on this bolt would ordinarily call for screw machining but the two lugs under the head ruled this out. Progressive cold-heading was Hassall's answer.

SPECIALTY MANUFACTURER OFFERS SAVINGS ON SMALL PARTS AND FASTENERS

Multiply these case histories a thousandfold and you'll get some idea of the variety of tough problems we crack, and the savings we effect for our customers in the course of a year.

Our cold-heading process—supplemented by secondary operations—imposes amazingly few limitations on the parts and fasteners we can make. Don't forget that we are not limited to "stock" sizes. These illustrations show that Hassall—a specialty supplier—can show you substantial savings, better deliveries and no-charge assistance at all times.

Proof? Send us your specifications or write for catalog.

John Hassall, Inc., P. O. Box 2197 Westbury, Long Island, New York.

HASSALL

SINCE 1850

NAILS, RIVETS, SCREWS AND OTHER COLD-HEADED FASTENERS AND SPECIALTIES

News Roundup

Chicago. Additional information may be obtained from society headquarters, 640 Engineers Bldg., Cleveland 14, O.

May 24-25—

Third Conference on Mechanisms to be held at Purdue University, West Lafayette, Ind. Sponsored by the Purdue School of Mechanical Engineering and MACHINE DESIGN. Additional information may be obtained from the Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, O.

May 28-30—

National Fluid Power Association. Spring Meeting to be held at the Greenbrier, White Sulphur Springs, W. Va. Barrett Rogers, 1618 Orrington Ave., Evanston, Ill., is executive secretary.

June 3-6—

American Gear Manufacturing Association. Annual Meeting to be held at the Homestead, Hot Springs, Va. John C. Sears, One Thomas Circle, Washington, D. C., is executive secretary.

June 3-8—

Society of Automotive Engineers Inc. Summer Meeting to be held at the Chalfonte-Haddon Hall, Atlantic City, N. J. Additional information may be obtained from society headquarters, 29 W. 39th St., New York 18, N. Y.

June 5-8—

Materials Handling Institute Inc. Materials Handling Exposition to be held at the Public Auditorium, Cleveland, O. Additional information may be obtained from society headquarters, One Gateway Center, Pittsburgh 22, Pa.

June 6-8—

American Society for Quality Control. Annual Meeting to be held at the Mt. Royal Hotel, Montreal, Quebec, Canada. Additional information may be obtained from society headquarters, 50 Church St., New York 7, N. Y.

June 11-12—

Malleable Founders' Society. Annual Meeting to be held at the Homestead, Hot Springs, Va. Low-

ell D. Ryan, 1800 Union Commerce Bldg., Clveland 14, O., is secretary.

June 11-15—

Society of the Plastics Industry Inc. National Plastics Exposition to be held at the Coliseum, New York. Additional information may be obtained from society headquarters, 67 W. 44th St., New York 36, N. Y.

June 14-16—

American Society of Mechanical Engineers. Applied Mechanics Division Conference to be held at the University of Illinois, Urbana, Ill. Additional information may be obtained from society headquarters, 29 W. 39th St., New York, N. Y.

June 17-20—

American Society of Agricultural Engineers. Annual Meeting to be held at Hotel Roanoke, Roanoke, Va. Frank B. Lanham, St. Joseph, Mich., is secretary.

June 17-21—

American Electroplaters Society. Annual Meeting to be held at Hotel Statler, Washington. Additional information may be obtained from society headquarters 445 Broad St., Newark, N. J.

June 17-21—

American Society of Mechanical Engineers. Semiannual Meeting to be held at Hotel Statler, Cleveland. Additional information may be obtained from society headquarters, 29 W. 39th St., New York, N. Y.

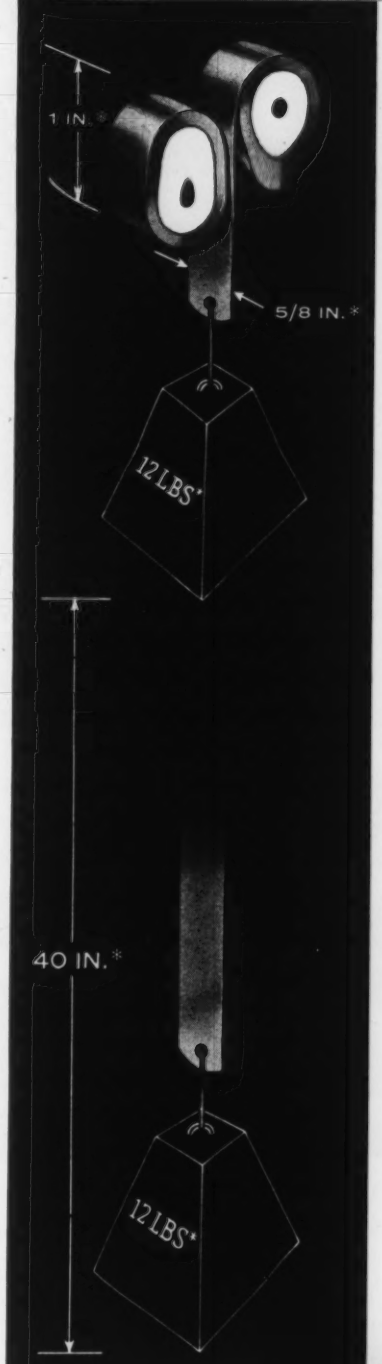
June 17-22—

American Society for Testing Materials. Annual Meeting and Apparatus Exhibit to be held at Chalfonte-Haddon Hall, Atlantic City, N. J. Robert J. Painter, 1916 Race St., Philadelphia 3, Pa., is executive secretary.

June 18-21—

Institute of the Aeronautical Sciences. Summer Meeting to be held at the IAS Bldg., Los Angeles. Additional information may be obtained from society headquarters, 2 E. 64th St., New York 21, N. Y.

BALANCE IT *with a*
NEG'ATOR® *constant-force spring*



* *Just an example*

NEG'ATOR is the name of a new kind of spring—the coiled-band spring that extends many times its original size without the increasing force common to conventional springs.

One of the natural uses of the NEG'ATOR Spring is counterbalancing without mass—vertically as illustrated, or horizontally. Using the NEG'ATOR Spring, the design engineer can eliminate dead weights or linkages and gain space, freedom of motion, reduced over-all weight, simplified assembly.

For example, each of the NEG'ATOR Extension Members used back-to-back in the illustration measures about 1 inch in diameter when coiled. They will counterbalance a 12 lb. weight over about 40 inches of travel. The only force required to move the weight is that required to overcome friction in the mechanism. There is no intercoil friction in the NEG'ATOR Spring.

NEG'ATOR Springs in extension or motor form are versatile in counterbalancing functions—are now being used to balance light tank floats in sensitive liquid-level indicators and fire doors and other heavy equipment. Extensions range to over 20 feet.

Used as an extension spring, a motor, band, clamp, or clip—this revolutionary new *constant-force* component upsets all previous spring principles, opens a whole new field of mechanical design by doing what springs have never done before.

These and other functions of Hunter NEG'ATOR constant-force springs are described in Bulletin 310N, "The Story of the NEG'ATOR Spring." Send for a copy.

HUNTER SPRING COMPANY
3 Spring Avenue, Lansdale, Pennsylvania
SPRINGS • STAMPINGS • TEST APPARATUS

—ITEM 570—

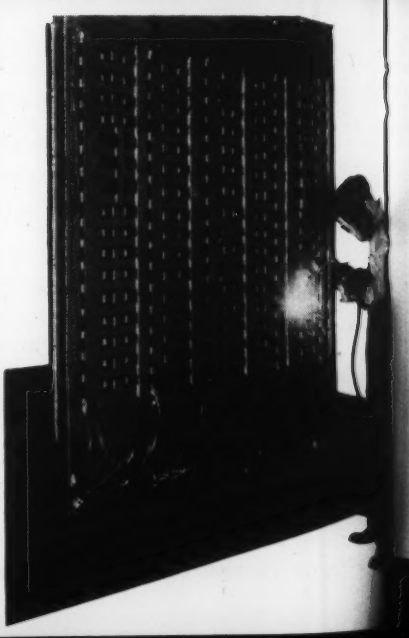
HOW USS "T-1" STEEL IMPROVES THESE PRODUCTS...

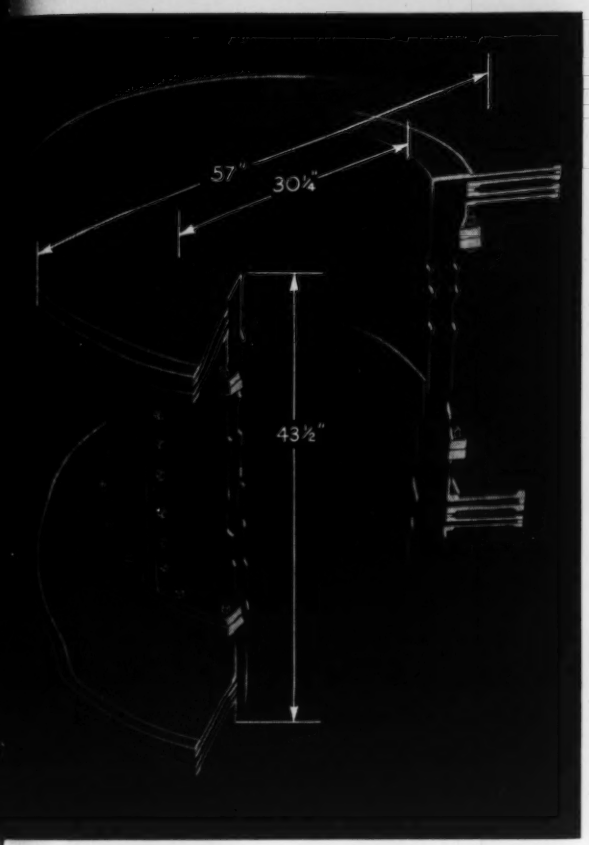
. . . Lops off 1,047 Pounds

Trays for ore clean-up buckets need tremendous resistance to impact, abuse and abrasion, Blaw-Knox Company, Pittsburgh, Pa., found that they weigh half a ton less, and cost less to fabricate when made from USS "T-1" Steel plate instead of heavy steel castings.

. . . 534 Easier Welds

This printing press bedplate, manufactured by Graver Tank & Manufacturing Co., Inc., must be welded in 534 places. High alloy steel with the needed strength was very difficult to weld. But USS "T-1" Steel is easy to weld . . . and has the needed strength to keep these bedplates, used on high-speed printing presses, as lightweight as possible.





. . . Saves $18,043

In structures like this, which are steel bellows that flex up-and-down and sideways, large thermal expansions can be accommodated. These expansion bellows surround struts which support a large axial flow compressor rotor. The bellows are connected from the compressor stator to the foundation. Westinghouse Electric Corporation switched to USS "T-1" Steel . . . promptly cut not only the cost of machining and welding, but also cost of the steel itself—saved $18,043.

. . . Three Ways Better

International Nickel Company of Canada expects USS "T-1" Steel to increase the service life, to reduce the maintenance, and lower the long-term cost of ore cars like this one; because "T-1" Steel has far greater strength, toughness, and resistance to abrasion than steel used previously. The car builder, Canadian Car and Foundry Co., Ltd., has had no difficulty fabricating this very strong alloy steel.

HOW USS "T-1" STEEL CAN HELP YOU

The great strength and toughness of USS "T-1" Steel (90,000 psi. minimum yield strength) helps you to increase the capacity and durability of power shovel buckets and storage tanks without increasing weight.

Its excellent weldability enables you to fabricate large equipment out in the field without heat treatment . . . thus, reduces fabricating and shipping costs and speeds up construction.

Its unusual toughness at sub-zero temperatures helps you to lengthen service life of equipment that must take impact, abrasion, and abuse in all weather.

USS "T-1" Steel also gives you good creep rupture strength to 900° F. It often can be substituted for more expensive steels that are more difficult to fabricate. There is a place for "T-1" Steel somewhere in your designs. Write, wire, or phone for more information. United States Steel, Room 5289, Pittsburgh 30, Pa.

UNITED STATES STEEL CORPORATION, PITTSBURGH → COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO · TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA.
UNITED STATES STEEL SUPPLY DIVISION, WAREHOUSE DISTRIBUTORS, COAST-TO-COAST · UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS "T" CONSTRUCTIONAL ALLOY STEEL

USS

UNITED STATES STEEL

Instantaneous Reset

Counts batches continuously without slow down and without missing a single count between batches.

Automatic Batch Control

Operates automatically to close chutes, operate diverter, start or stop conveyor, machine, etc.

Electric Actuation

May be located remote from the source of actuation (switch, relay, photoelectric unit or other circuit breaking device).

Models to fit the job

Full range selection; permits quick setting for any batch quantity within the range of the counter (ranges to 10,000).

Limited selection; permits quick setting to certain batch quantities for which the counter is built.

Wide Choice of Features

Warning or preliminary control, built-in totalizing counters, remote starting and stopping, and many others.

Send for literature

with application case histories or tell us about your requirements.

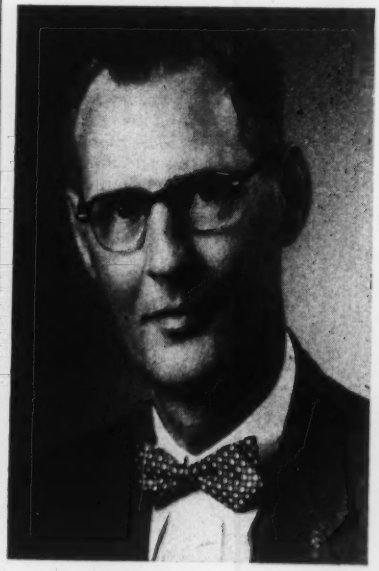
PIC
PRODUCTION INSTRUMENT CO

702-08 W. Jackson Chicago 6, Ill.

—ITEM 572—

Men of Machines

General Electric Co. has announced the appointment of **Ralph E. Coutant** as manager of engineering of its new Gear Motor and Transmission Components Department in Paterson, N. J. Mr. Coutant was associated with GE as an ap-



Ralph E. Coutant

prentice draftsman for several years before earning his degree in mechanical engineering. He then returned to the company as a design engineer and, in 1941, was named project engineer in marine and aircraft engineering. Later he was appointed assistant to the manager of marketing in the Aeronautics and Ordnance Div., and since May 1955 has served as engineering consultant to the Gear Motor Planning Study group.

Henry H. Hausner has joined Penn-Texas Corp., New York, as general manager of its Nuclear Engineering Div. He will be responsible for co-ordination of the nuclear engineering activities of the parent corporation and its subsidiaries and will also act as consultant to other firms. At Penn-Texas, Dr. Hausner will supervise research and development of nuclear reactor materials and components and will advise on the application of nuclear energy for industrial purposes.

Arthur H. Jones has been appointed director of engineering of the National Defense Department of Motorola Inc., Chicago. He was formerly vice president of engineering for Frank C. Brown and Co. Inc.

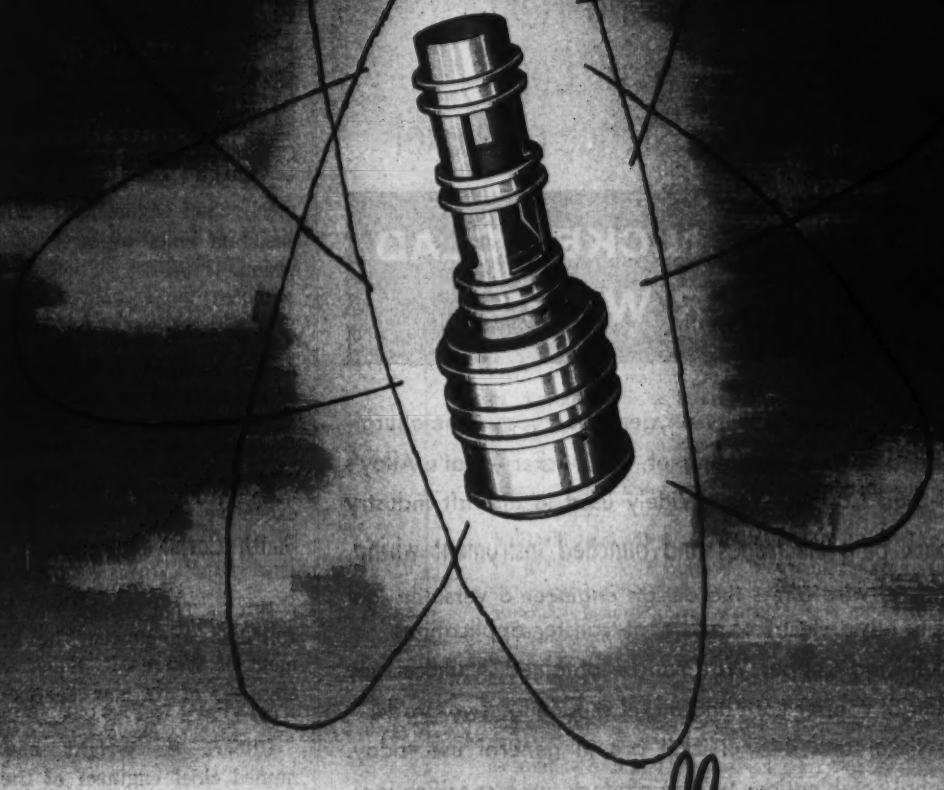
James M. Phillips has been elected vice president of engineering of Salem-Brosius Inc., Pittsburgh. Mr. Phillips has been chief engineer of the company since July, 1955. Prior to that time he had been vice president of Phillips Corp. and its predecessor, Phillips Mine and Mill Supply Co.

James M. Phillips

Paul Hafer, formerly vice president in charge of engineering for Continental Electric Equipment Co., Ludlow, Ky., has been appointed superintendent of the Great Lakes Regional plant of Federal Pacific Electric Co., Cleveland.

Controls Corp. of America, Schiller Park, Ill., has announced that **Donald M. Strathhearn Jr.** has

MAKES STAINLESS STEEL HARDER THAN DIAMONDS



Super Scottsonizing serves *all* industries

You know there is nothing harder than diamonds, but stainless steel precision parts that have been Super SCOTTSONIZED have scratched diamonds! Leading manufacturers of electronic devices, plastics, aircraft, and experimental laboratories rely on Super SCOTTSONIZING to make stainless steel "hard enough to scratch a diamond."

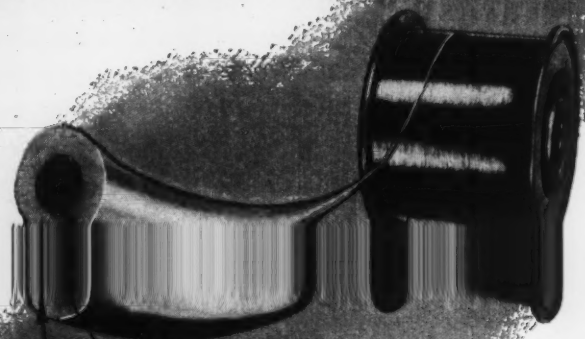
For precision parts and instruments that require long, superior service and durability, use Super SCOTTSONIZING.

C. U. [redacted] & SON, INC.

EST. 1906

Commercial Heat Treating Specialists **1510 First Avenue, Rock Island, Illinois**

THE 2 IN 1 WIRE THAT GIVES YOU...



Electrical and Heat Conductivity of Copper plus Heat Resistance of Nickel

ALLOY'S NICKEL-CLAD COPPER WIRE

A core of high conductivity oxygen-free copper, metallurgically bonded to a sheathing of "A" Nickel—that's Alloy's Nickel-Clad Copper Wire. Widely used in aircraft industry for spark plug electrodes and bunched instrument wiring, this bimetal wire offers the design engineer a versatile tool for many other electrical and heat-transfer applications.

Nickel-Clad Copper Wire can be obtained in almost any variation of copper core and nickel sheathing. Two grades—27% Nickel and 64% Nickel are in general use today. Additional combinations will be made to your specifications.

Other clad-metal wires are also available, including Inconel-Clad Copper and Inconel-Clad Nickel.

For complete engineering and application data on our Nickel-Clad Copper Wire, send today for Technical Bulletin T-3.

ALLOY METAL WIRE DIVISION

H. K. PORTER COMPANY, INC.
Prospect Park, Pennsylvania

Men of Machines

joined the Soreng Div. as vice president and director of engineering.

Robert L. Collins has been appointed manufacturing manager of the Special Products Div. of Ford Motor Co., Dearborn, Mich. He was formerly supervisor of the manufacturing engineering services section for the Ford division and, since 1949, has held various other supervisory positions in that division.

Skinner Chuck Co. and Skinner Electric Valve Div., New Britain, Conn., has appointed **George Goepfrich** director of engineering and development and **Robert B. Clay** chief engineer of the Electric Valve Div. Mr. Goepfrich was formerly chief engineer and Mr. Clay, assistant chief engineer of the division.

Bendix Aviation Corp. recently named **Richard M. Somers** director of engineering of its Kansas City, Mo. division.

D. W. Sherman has been named executive staff engineer by A. O. Smith Corp., Milwaukee.

Illinois Tool Works, Des Plaines, Ill., has announced the appointment of **Warren R. Black** as chief engineer of its new Fastex Div.

Gilbert S. Wright has been named chief engineer of the press and special machinery department of A. B. Farquhar Div., Oliver Corp., York, Pa.

Infra Electronics Corp., Roseland N. J., recently promoted **Fenimore Fisher** to chief engineer of its large motor and generator division. Mr. Fisher was senior engineer in the servo motor laboratory. Prior to joining Infra, he was a design engineer at the Naval Aircraft Instrument Laboratory in Philadelphia.

Vladimir A. Sklodowski has been appointed manager of the Human Engineering Section, Crosley Government Products Div., of Avco Mfg. Corp., Cincinnati.

Men of Machines

Ronald L. Loup

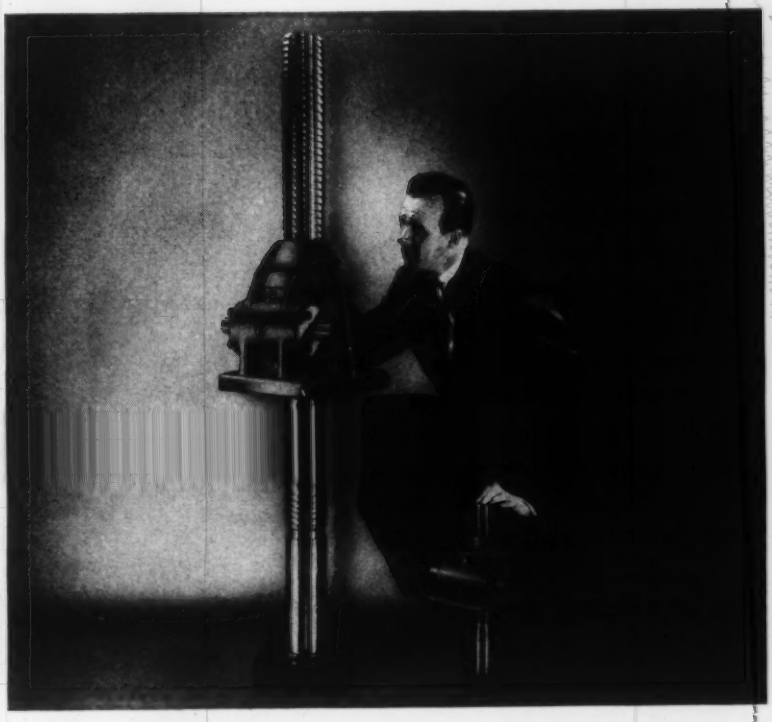
Progressive Welder Sales Co., Detroit, has appointed **Ronald L. Loup** director of engineering for all divisions. Mr. Loup recently was made chief engineer of the welding machine division.

The Trane Co., La Crosse, Wis., has promoted three senior development engineers in its Products Engineering Department to chief engineers. **R. G. Miner Jr., E. T. Neubauer** and **A. M. G. Moody** will assume added responsibilities in their respective fields by heading the controls and electrical, reciprocating compressor, and centrifugal compressor phases of the firm's product development program.

John E. Clemens has been named head of a research unit opened recently in the Dayton, O. area by the United Shoe Machinery Corp. **Ben B. Johnstone** will assist Dr. Clemens in the technical direction of the new facility.

Robert R. Johnson has been named chief engineer by Minnesota Rubber and Gasket Co., Minneapolis.

WacLine Inc., Dayton, O., has announced the appointment of **Eugene B. Johnston** as project engineer in charge of research and development of instruments and equipment for medical research and treatment.

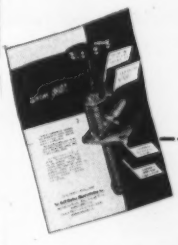


Here's A Device Every Machinery Designer Should Know About . . .

It's the Duff-Norton Worm Gear Jack, successfully used by many machine builders as a component of equipment for precise, positive control of linear motion, applying pressure, resisting impact. Two or more of these jacks can be connected by means of shafting and mitre gear boxes to give a positive drive, so that jacks always raise or lower under equal or unequal loads in perfect unison. Capacities range from 5 to 50 tons with any raise up to 25 inches; worm gear ratios, 8:1 to 96:1; turn of worm for each 1-inch raise, 10 to 180; available in either Acme or square threads. For protection against foreign matter certain models can be furnished with bellows boots.

Thousands of these jacks are in use today for table adjusting—machine adjusting—rolling mill adjusting—raising and lowering conveyors, machine beds, molds and dies, furnace lids, loading platforms, loading racks, gates, hinged mechanisms, arbor presses—adjusting electrodes—overhead crane servicing.

Duff-Norton Worm Gear Jacks are available in 6 standard sizes. For complete specifications and detailed drawings, send for your free copy of a special brochure.



DUFF-NORTON Company

DUFF-NORTON COMPANY
Department MD
P.O. Box 1889, Pittsburgh 30, Pa.

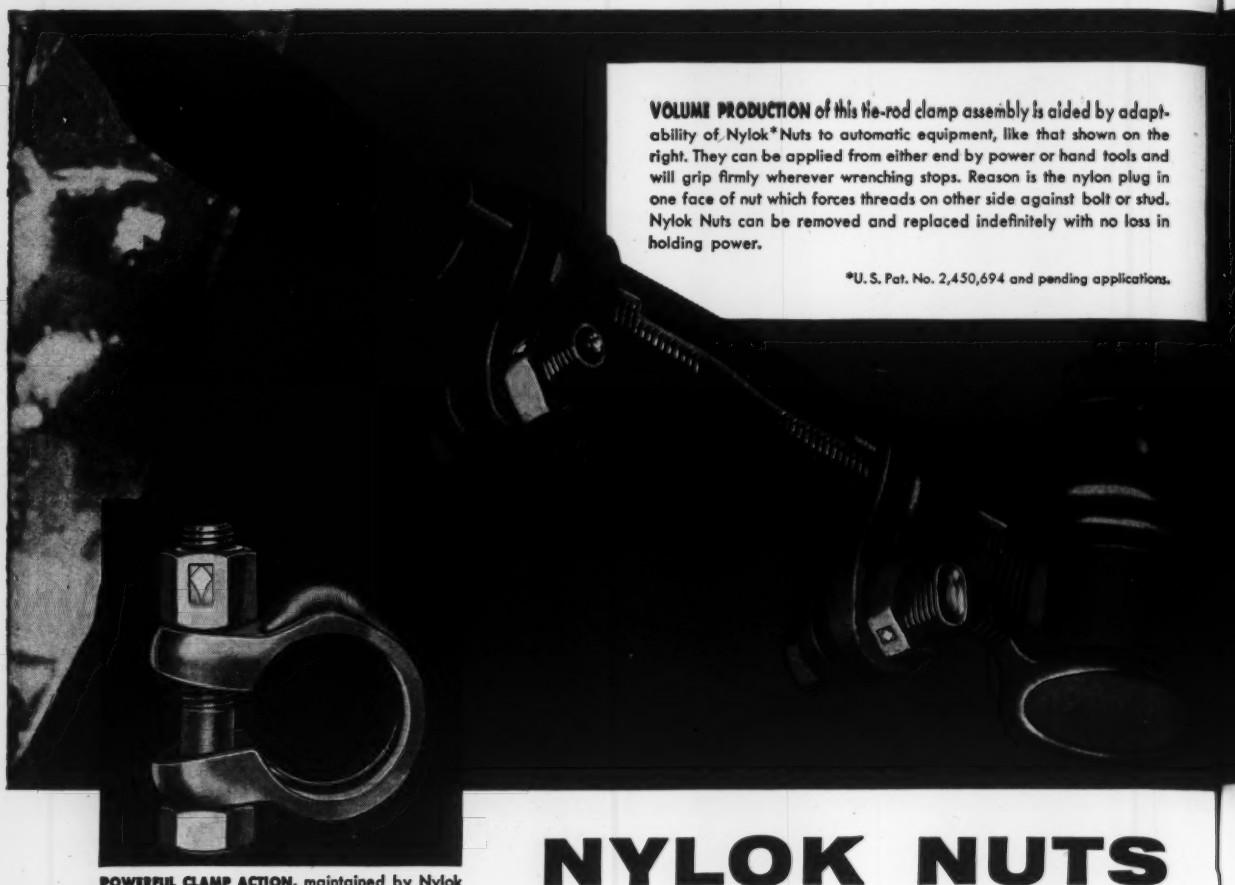
Please send immediately a free copy of your new Worm Gear Jack Brochure.

NAME TITLE

COMPANY PHONE

ADDRESS

—ITEM 575—



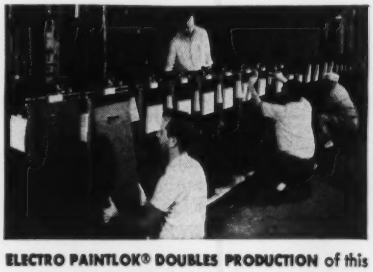
VOLUME PRODUCTION of this tie-rod clamp assembly is aided by adaptability of Nylok* Nuts to automatic equipment, like that shown on the right. They can be applied from either end by power or hand tools and will grip firmly wherever wrenching stops. Reason is the nylon plug in one face of nut which forces threads on other side against bolt or stud. Nylok Nuts can be removed and replaced indefinitely with no loss in holding power.

*U. S. Pat. No. 2,450,694 and pending applications.

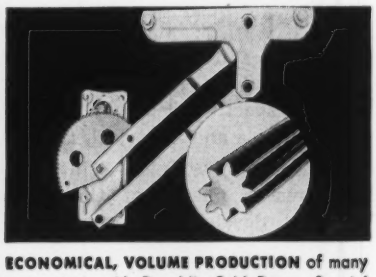
POWERFUL CLAMP ACTION, maintained by Nylok Nuts, keeps vital steering tie-rod assembly securely in adjustment. Republic Nylok Nuts are currently in use on thousands of critical applications subject to shock, vibration and cyclic loading. Clip and mail the coupon for details.

NYLOK NUTS provide positive

FAST PRODUCTION of quality spouts for these oil dispensers is secured by using Republic ELECTRUNITE® Mechanical Tubing. The manufacturer, Swingspout Measure Company, Los Angeles, California, finds ELECTRUNITE easy to swedge and bend as required. Because Republic controls quality from ore to finished tubing, uniform strength, cross-section and ductility are assured. These characteristics underwrite quality in products fabricated from ELECTRUNITE. Send coupon for literature.



ELECTRO PAINTLOK® DOUBLES PRODUCTION of this water cooler manufacturer's painting and drying facilities. How? Because for this particular job Republic Electro Paintlok requires only one pass through paint shop and drying oven instead of two trips needed for uncoated sheets. Also, Electro Paintlok produces a superior finish. Its chemically treated coating actually grips paint . . . and even when scratched, limits corrosion to point of damage. Mail coupon for data.

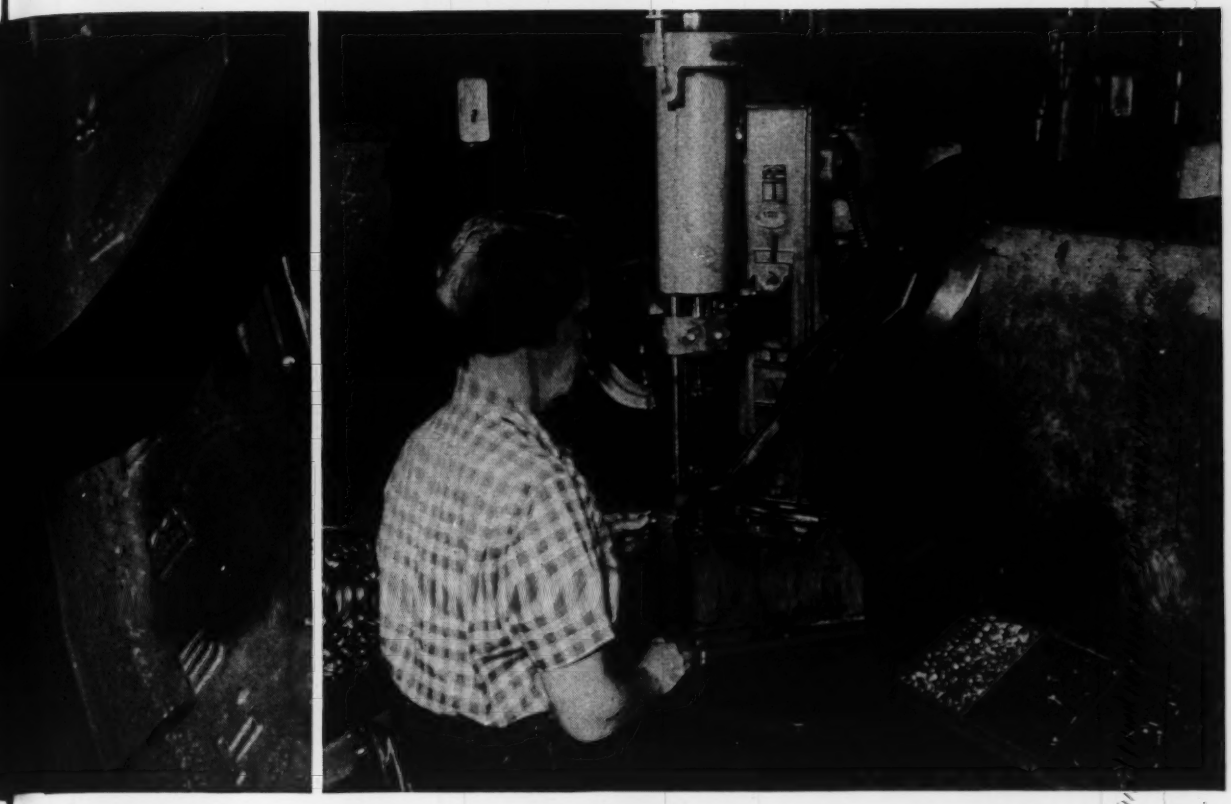


ECONOMICAL, VOLUME PRODUCTION of many parts starts with Republic Cold Drawn Special Sections. For example, the gear shown on this automobile window lift assembly is simply cut from a special section and drilled. In other cases, machining is minimized or eliminated entirely, thanks to fine surface and close tolerance produced by cold drawing. Design to take advantage of special sections and save. For facts, send coupon.

REPUBLIC

REPUBLIC STEEL

World's Widest Range of Standard Steels



SPEED PRODUCTION...

locking and easy adjustment

In line with current emphasis on safety equipment in the automotive industry, engineers are studying every detail to assure maximum operating security. That's one of the reasons why Thompson Products, Inc., Michigan Division, has switched to Nylok Nuts for their steering tie-rod clamp assembly . . . produced for several top automobile manufacturers.

Actually, Thompson has found Nylok Nuts ideal for this application from several standpoints. For instance, they speed production by eliminating handling and assembly of lock washers... and since either end is up, Nylok Nuts are ideal for automatic feeding and power wrenching. In addition, they lock tightly even when not seated. Pre-assembled clamps can be freely handled with no possibility of losing the nut or bolt.

Finally, Nylok Nuts retain their grip after any number of tie-rod adjustments. They can be easily backed off with hand tools, and after the adjustment is made, wrenched tight again to stay.

Republic Nylok Nuts have been used in countless applications to speed assembly and provide maximum holding power under all conditions. Why not check your product to see where they will work to advantage for you? For complete information, contact your local Republic Bolt and Chain Division representative, or mail the coupon.

STEEL

and Steel Products

REPUBLIC STEEL CORPORATION
Dept. C-1309
3130 East 45th Street
Cleveland 27, Ohio

Please send me further data on:

- ☐ Nylok Nuts ☐ Electro Paintlok
- ☐ ELECTRUNITE Mechanical Tubing
- ☐ Cold Finished Special Sections

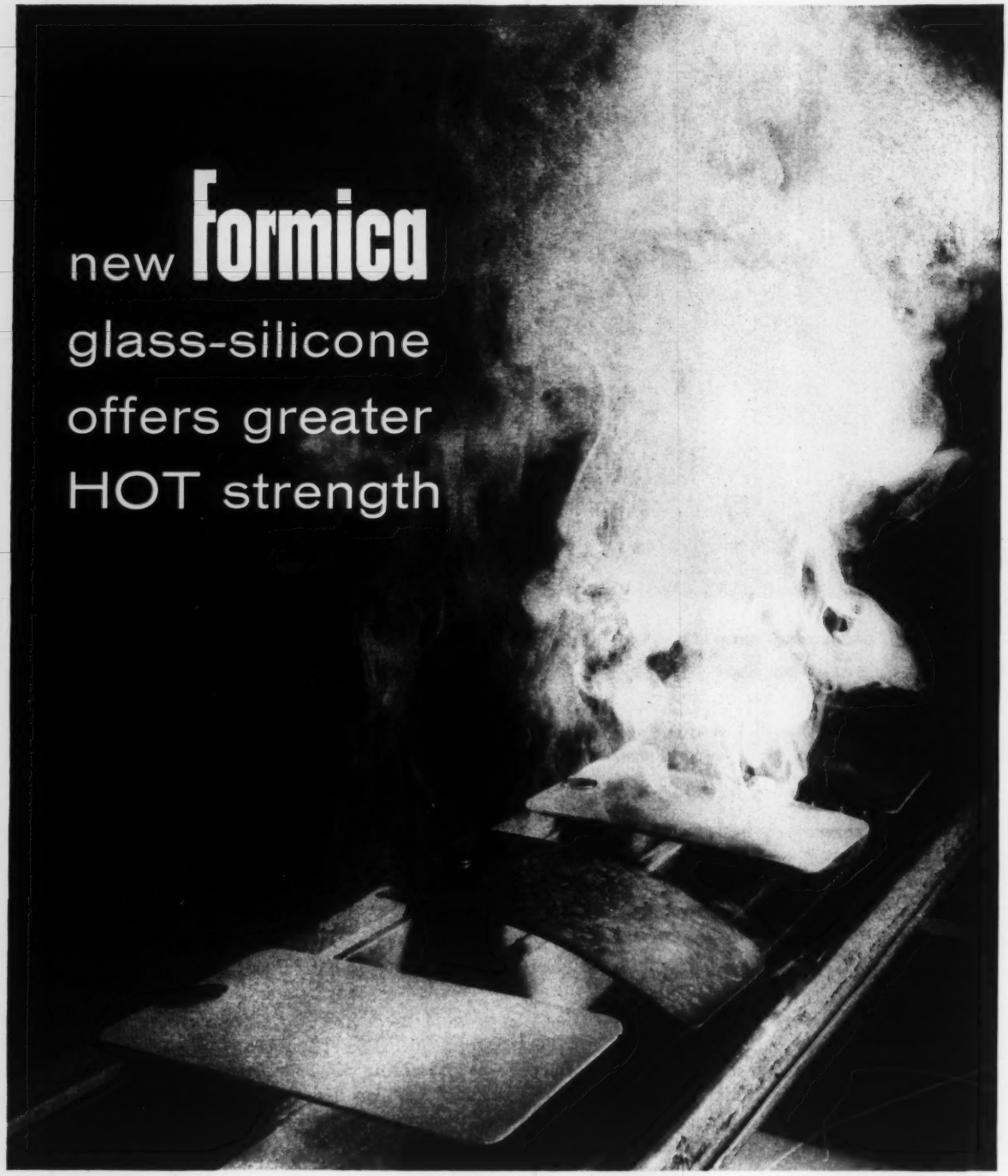
Name_____ Title_____

Company_____

Address_____

City_____ Zone____ State_____

—ITEM 576—



New Formica G-7-2 silicone offers five characteristics for broader application:

1. Greater hot strength.
2. Lower moisture absorption (.12% after 24 hrs. immersion).
3. Lower wet power factor (.008).
4. Larger and thicker sheets (up to 36″ x 72″ x 2″).
5. Uniform creamy white color.

The photo above dramatically demonstrates the outstanding hot strength property of Formica's new G-7-2. A withering blast from the lab heater causes three ordinary laminated plastics to smoke, char, blister and bend. But G-7-2 comes through this grueling test unmarked, its mechanical and electrical properties virtually unaffected.

G-7-2 is approved under military spec MIL-P-997-B, type GSG.

The unusual properties of G-7-2 are especially useful in guided missiles, radar, radio and tv, motors and generators and other electrical/electronic applications. Recommended for printed circuitry. For complete information, send today for free G-7-2 data sheets. The Formica Co., 4545 Spring Grove Ave., Cincinnati 32, O.

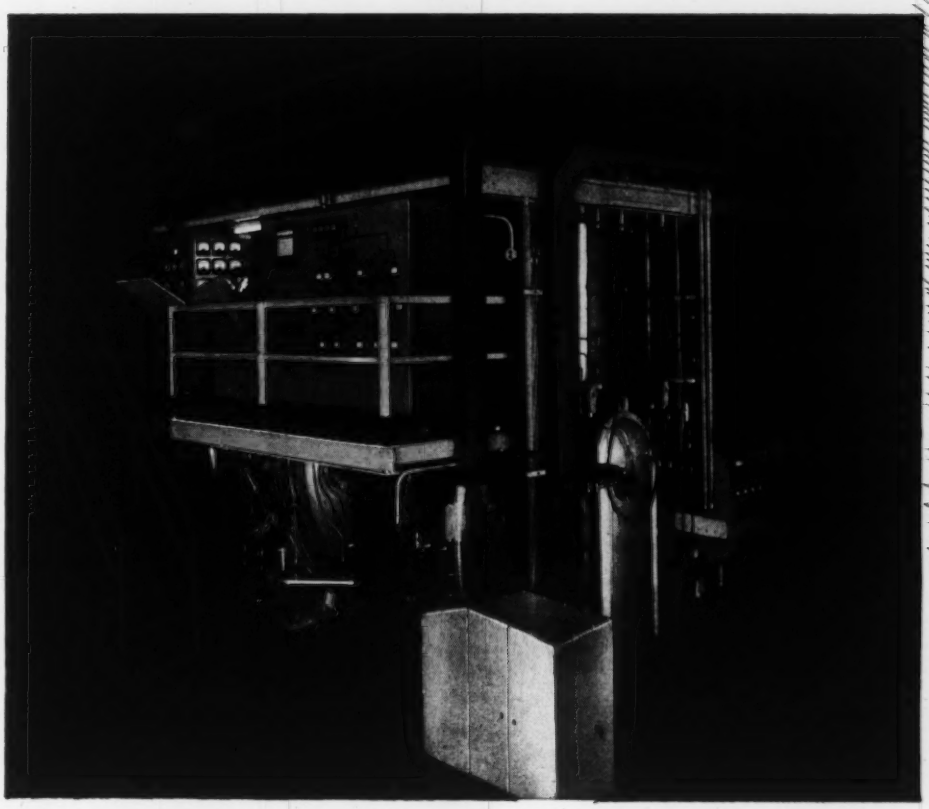
Formica-4 FI-1153
makes Formica 1st choice in laminated plastics.

FORMICA 4

Application engineering • Fabricating
Research • Customer stock service

—ITEM 577—
For More Information Circle Item Number on Yellow Card—page 19

NATION'S LARGEST VACUUM FURNACE POURS INGOTS UP TO 2500 POUNDS



SYRACUSE, N. Y. — Vacuum Metals Corporation has completed testing and evaluation of the newest and largest vacuum induction furnace in the country. Capable of producing up to 2500 pounds of vacuum-melted metal per heat, this furnace will make possible the production of larger rolled forms than ever before, as well as an increased number of smaller rolled forms from a single heat.

Vacuum Metals Gives You One-Source Service

The new furnace marks the end of the first stage in Vacuum Metals Corporation's current expansion program. It lends further significance to our ability to offer complete, *one-source* service in the field of vacuum-melted metals.

This unique service is made possible not only by Vacuum Metals Corporation's own large organization, but through its affiliation with National Research Corporation and Crucible Steel Company of America. It includes everything from furnace design through melting and casting, to mill rolling and nationwide distribution and service of finished mill products.

Products Show Remarkable Properties

Because of the extensive technical, service and sales organizations available to Vacuum Metals Corporation, the unusual properties of vacuum-melted metals are now available to American industry on an unprecedented scale. These properties include remarkable cleanliness, greater uniformity, higher impact and fatigue strengths, special electrical and magnetic characteristics. They are inherent benefits of the vacuum-melting process. Use of materials produced by this process frequently results in unusual bonuses of design freedom, improved service characteristics, and longer life.

Details on the applications of vacuum-melted metals are available through any branch office of Crucible Steel Company, or directly from Vacuum Metals Corporation. In requesting information, please include as detailed a description as possible of the application in which you are interested. *Vacuum Metals Corporation, P. O. Box 977, Syracuse 1, N. Y.*

VMC

VACUUM METALS CORPORATION

Jointly owned by Crucible Steel Company of America and National Research Corporation

G-E general purpose control

GIANT SAW EQUIPPED WITH G-E CONTROL SLICES 3½-FOOT ALUMINUM INGOTS

This specially designed high-speed circular saw, one of the largest of its kind ever manufactured, is installed in the U.S. Air Force plant No. 47, operated for the Air Force by Aluminum Company of America and located in Cleveland, Ohio. The saw cuts aluminum ingots up to 43 inches thick in preparation for the forging of wing spars for jet aircraft.

Manufactured by Motch and Merryweather, the huge saw is equipped with General Electric control. The main control panel shown here is custom-made for this particular application, yet contains standard high-quality G-E relays, magnetic contactors and starters, and other devices.

on machines for industry

G-E Oil-tight Push Buttons Control 23 Operations on Giant Saw

Motch and Merryweather engineers specified G-E oil-tight push buttons for this giant saw because of their exceptionally long service life, and their ability to keep out the fine aluminum chips which might cause ordinary push buttons to fail. Also, the proved dependability of these pushbutton units assured customer satisfaction.

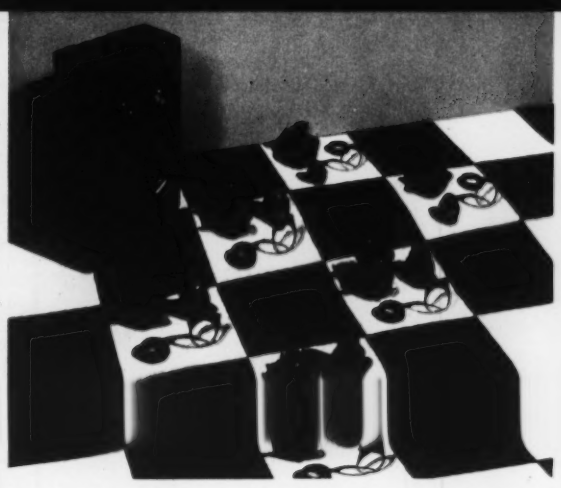
Twenty-three push buttons and selector switches were mounted in the separate control station, shown at right. The Motch and Merryweather engineers found the brilliantly colored pushbutton rings helped achieve the modern, streamlined appearance of this colorful machine.

Why don't you check into the possibility of using G-E oil-tight push buttons for your machines? Write for bulletin GEA-5779, Section 731-1, or contact your nearest G-E Apparatus Sales Office or Distributor.

GENERAL ELECTRIC

BLOOMINGTON, ILLINOIS

COMPLETE SELECTION—UNEQUALED FLEXIBILITY—WITH G-E OIL-TIGHT PUSH BUTTONS



UNEQUALED FLEXIBILITY is provided. The same contact block can be used either singly or in combination with all of the separable operators. The glass lenses for all the indicating lights are also interchangeable.

COMPLETE SELECTION of push buttons, selector switches, and indicating lights is available. Using various arrangements of color rings, operators, and contact blocks, hundreds of combinations are available.

THE SECRET INGREDIENT

Experience is the "hidden plus" that is built into every Torrington air-impeller design... experience derived from the development of literally thousands of design variations created to meet the performance requirements of products valued at nearly four billion dollars a year!

Typical of Torrington's product range in immediately available production equipment:

P SERIES: *A high-performance fan blade designed for a wide variety of medium pressure applications.*

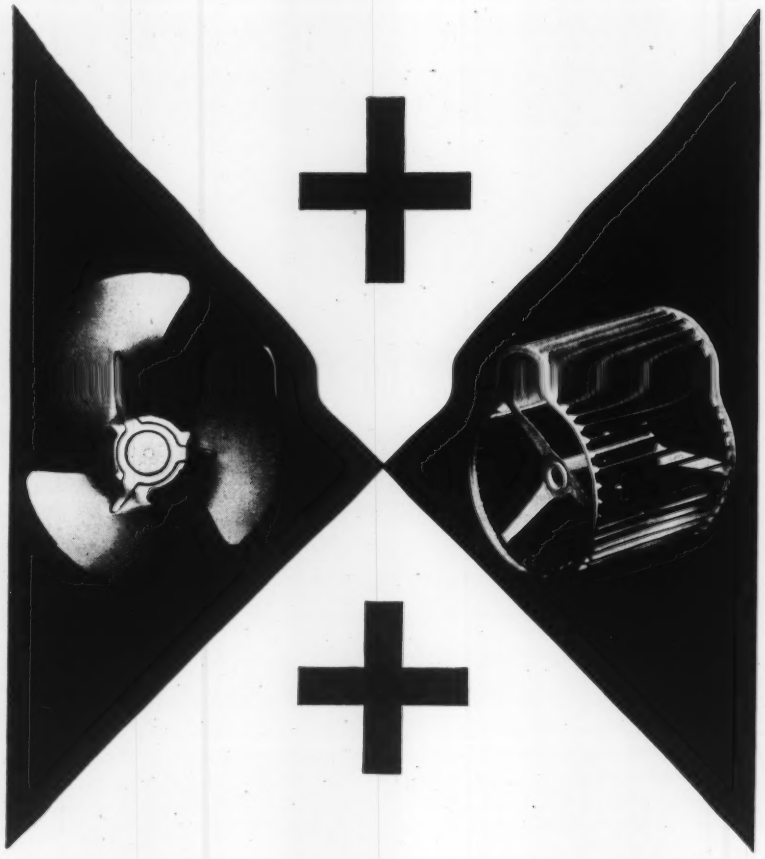
Y AND YL SERIES: *A 3-bladed adaptation of the "S Series" fan blade which gives top performance in many low pressure or free air applications.*

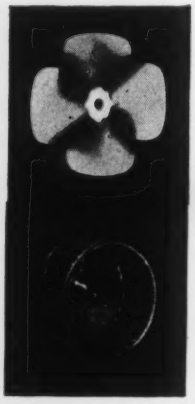
L AND LU SERIES: *A one-piece fan blade available at low cost designed for especially quiet operation in many applications. LU fan pierced for unit bearing motors. L fan equipped with regular hub.*

M SERIES: *Knocked-down construction of this attic fan blade saves space and shipping costs. Quickly assembled with no special tools.*

AIROTOR BLOWER WHEELS: *Single wheel, double wheel and "X" Type double intake wheel designs, available with special spline, jaw or short hub.*

Torrington's research, development and testing laboratories are available to you for the solution of any air-impeller problems relating to new product design.





THE
TORRINGTON
MANUFACTURING COMPANY
TORRINGTON, CONNECTICUT
VAN NUYS, CALIFORNIA · OAKVILLE, ONTARIO

—ITEM 580—

1936

Graham

1956

most reliable variable speed drive made

'36 '37 '38 '39 '40 '41 '42 '43 '44 '45 '46 '47 '48 '49 '50 '51 '52 '53 '54 '55

20 YEARS PROOF OF . . .

Reliability

Dozens of leading manufacturers of pumps, welding positioners, conveyors, and many other machines where continuous, unfailing operation is paramount, select this drive — because of dependability.

Accuracy

The Graham is *guaranteed* to give greater accuracy of speed holding, speed setting and speed resetting, without need of auxiliary governing device, than any other variable speed drive made — mechanical, electrical, electronic or hydraulic. On applications such as controlling the cut-off knife to maintain uniform length of rods, tubes, sheets, etc., the Graham has maintained measured accuracy in continuous 24 hour-a-day operation within .04 of 1%. This you get in the Graham without added cost.

Economy

The standard Graham costs no more than ordinary belt-type transmissions and in many applications the Graham is lower-priced because — unlike belt and other drives, it incorporates both speed variation and speed reduction and so saves the expense of costly speed reducers.

SIZES FROM FRACTIONAL TO 3 H. P.

There are four sizes of Graham — each in a wide variety of styles. All drives may be had either with built-in motor or with input shaft extension for coupling or belting to separate motor or to a shaft of the machine. Controls are either single turn, micrometer, lever or remote electrical control with speed indication at the remote point. Built-in motors may be had of nearly any desired mechanical and electrical type, open, totally enclosed, explosion-proof, motor with built-in brake included.

6 OUTSTANDING FEATURES

- Ultimate in simplicity and compactness.
- Unlimited speed range — from any desired maximum down to zero — including reverse if wanted without stopping the motor.
- Unmatched for accuracy of speed setting and resetting and speed holding.
- No perishable parts.
- Twenty year performance record.
- Low cost.

COMPLETE LINE OF BUILT-IN GEAR BOXES

The Graham gives every speed from any desired maximum down to zero (including reverse if wanted, without stopping the motor). The Graham should be so selected that the desired maximum speed of the driven shaft is had when the Graham is running at approximately its top speed. When this requires reduction or step-up gearing, this may be had without the cost and complication of a separate gearbox since the Graham is available with built-in single reduction or step-up spur gearing, single reduction worm gearing with output shaft horizontal or vertical, and double reduction helical gearing. Only four mounting bolts are required for the entire assembly — transmission, built-in motor and built-in gearbox — the ultimate in compactness.

GET Graham

most reliable variable speed drive made

Because engineered and rated for continuous 'round the clock service

Mail This Coupon NOW . . .

GRAHAM TRANSMISSIONS, INC.

DEPT. MD, MENOMONEE FALLS, WISCONSIN

Gentlemen: Please send your latest catalog on *Graham Variable Speed Drives.*

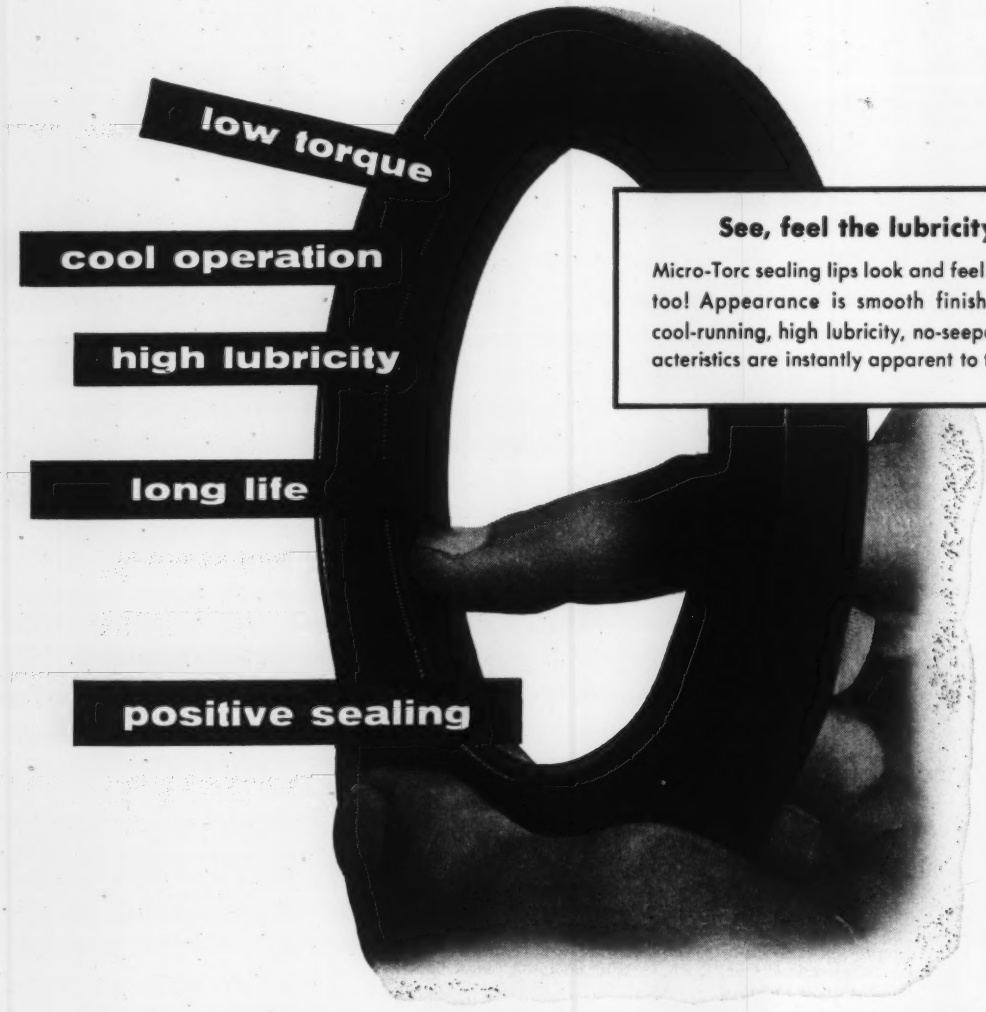
Company.....

Name..... Title.....

Address.....

City..... Zone..... State.....

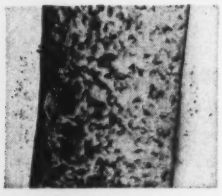
—ITEM 581—



See, feel the lubricity!

Micro-Torc sealing lips look and feel different, too! Appearance is smooth finished; their cool-running, high lubricity, no-seepage characteristics are instantly apparent to the touch!

NATIONAL MICRO-TORC* LEATHER OIL SEALS



How Micro-Torc works—Side of chrome retanned leather lip is coated with dry lubricant and elastomer. Elastomer binds lubricant to leather, prevents seepage through leather, enhances mechanical stability—yet permits leather's natural porosity to remain in body of sealing lip. Lip actually stores oil for dry or emergency running!

For applications where temperatures are within —50° to 200° F, maximum shaft speed is 2,000 fpm, and runout is held to about 0.005", new National Micro-Torc oil seals should definitely be investigated.

The Micro-Torc sealing member is perhaps the most interesting advance in leather oil seals in 15 years. In hundreds of thousands of hours of actual application, Micro-Torc seals have consistently shown up to 80% less torque and 10 times the life of other leather seals. Breakaway torque is normally only 20% of conventional leather seals, and Micro-Torc seals have operated up to 100 hours dry at 1,350 rpm without sloughing or squealing. Properly used, Micro-Torc seals provide positive sealing throughout service life.

Get complete details. Call nearest NMB Engineer, or write for Bulletin.

Engineering help in your plant and ours. NMB'S Application Engineering Service is fast, expert, convenient. Yours for the asking:

CHICAGO, ILL.	*Room 462 McCormick Building, HArrison 7-5163*
CLEVELAND, OHIO	*210 Heights Rockefeller Bldg., YEllowstone 2-2720*
DALLAS, TEXAS	*2520 West Mockingbird Lane, DIxon 7541*
DETROIT, MICH.	*13836 Puritan Avenue, VErmont 6-1909*
DOWNEY (Los Angeles Co.), CALIF.	*11634 Patton Rd., TOpaz 2-8163*
INDIANAPOLIS, INDIANA	*2802 North Delaware Street, WAlnut 3-1535*
KANSAS CITY, MO.	*4445 Terrace, LOgan 6622*
MILWAUKEE, WIS.	*647 West Virginia Street, BRoadway 1-3234*
NEWARK, N. J.	*1180 Raymond Blvd., MItchell 2-7586*
REDWOOD CITY, CALIF.	*Broadway and National, EMerson 6-3861*
WICHITA, KANSAS	*519 South Broadway, AMherst 2-6971*

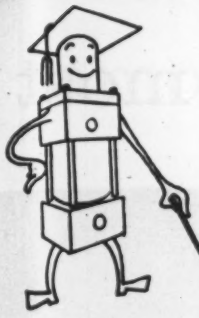
*T.M.REG.

NATIONAL
OIL & GREASE SEALS
O-RINGS SHIMS
Product of the world's largest exclusive manufacturer of oil seals

3675

NATIONAL MOTOR BEARING CO., INC.

Plants at Van Wert, Ohio, Redwood City, Downey and Long Beach, Calif.
General Offices: Redwood City



Miller

FLUID PRESSURE BOOSTERS

- Save space, weight and investment cost by replacing pump installations in many applications
- Less costly to install, operate and maintain
- **Hold pressure indefinitely** without the motion and heat generation of ordinary pump circuits
- Provide — at point of cylinder thrust — more efficient power with less weight in less space than direct driven air cylinders
- Save up to 95% of air consumed by direct driven air cylinders
- Operate at speeds of 30 to 450 strokes per minute

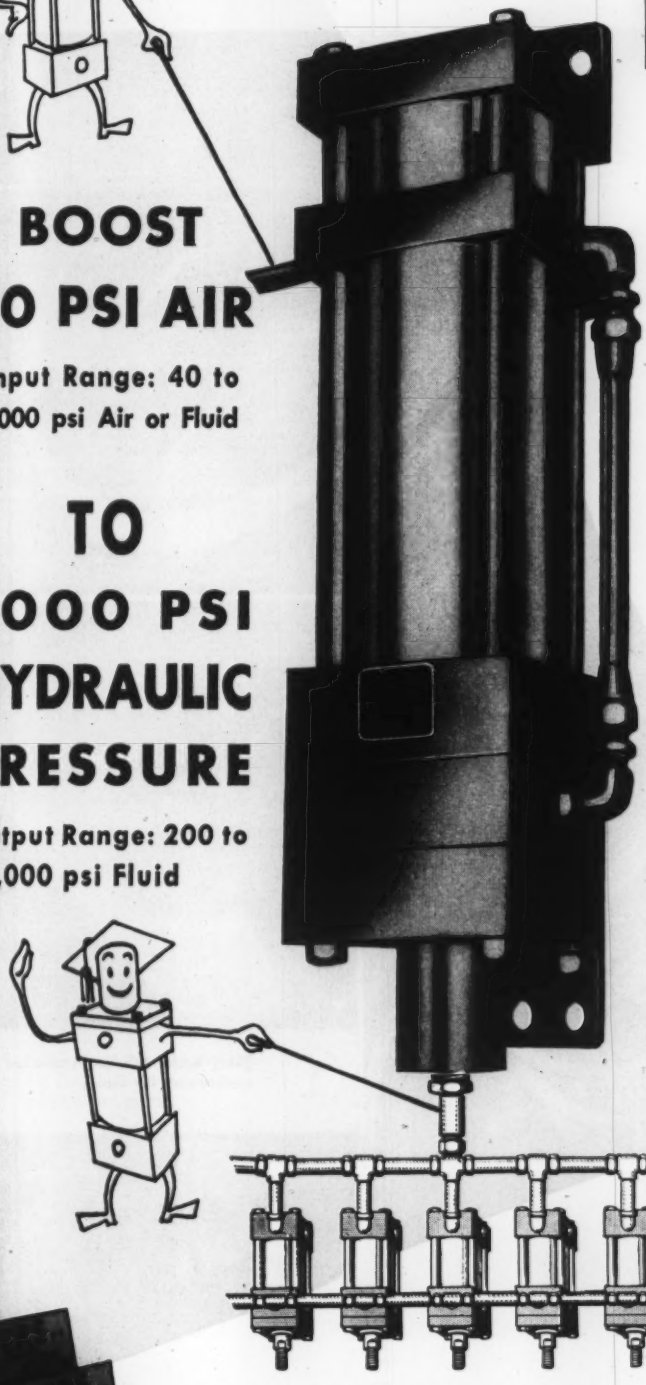
NOTE: In addition to its most complete line of "Custom-Built" Boosters available on normal delivery, Miller offers 5" bore, 25 to 1 ratio boosters for immediate delivery in either 6" or 12" stroke. Write for data and prices.

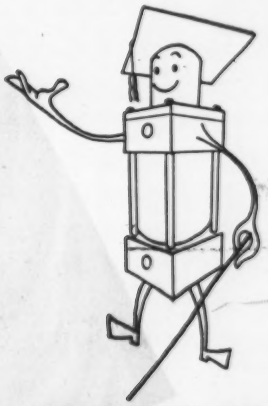
BOOST 80 PSI AIR

Input Range: 40 to 3000 psi Air or Fluid

TO 2000 PSI HYDRAULIC PRESSURE

Output Range: 200 to 10,000 psi Fluid





ESPECIALLY RECOMMENDED FOR

- **WELDING**
- **PUNCHING**
- **SHEARING**
- **CLAMPING**
- **RIVETING**
- **CRIMPING**
- **PRESSING**

and similar applications

FULL DETAILS IN MILLER BULLETIN B-200 SENT FREE ON REQUEST
Other Miller products include: Air cylinders, 1½" to 20" Bores, 200 PSI operation; low pressure hydraulic cylinders, 1½" to 6" bores for 500 PSI operation, 8" to 14" bores for 250 PSI; high pressure hydraulic cylinders, 1½" to 12" bores, 2000-3000 PSI operation. All mounting styles available.

SALES AND SERVICE FROM COAST TO COAST

CLEVELAND • YOUNGSTOWN • DAYTON • PITTSBURGH • PHILADELPHIA • BOSTON • HARTFORD • NEW YORK CITY • BUFFALO • ST. PAUL • GRAND RAPIDS • DETROIT • FLINT • FORT WAYNE • SOUTH BEND • INDIANAPOLIS • MILWAUKEE • LOUISVILLE • KANSAS CITY • SEATTLE • LOS ANGELES • SAN FRANCISCO • BALTIMORE • DENVER • ST. LOUIS • MOLINE • CHICAGO • HOUSTON • TORONTO, CANADA and OTHER AREAS

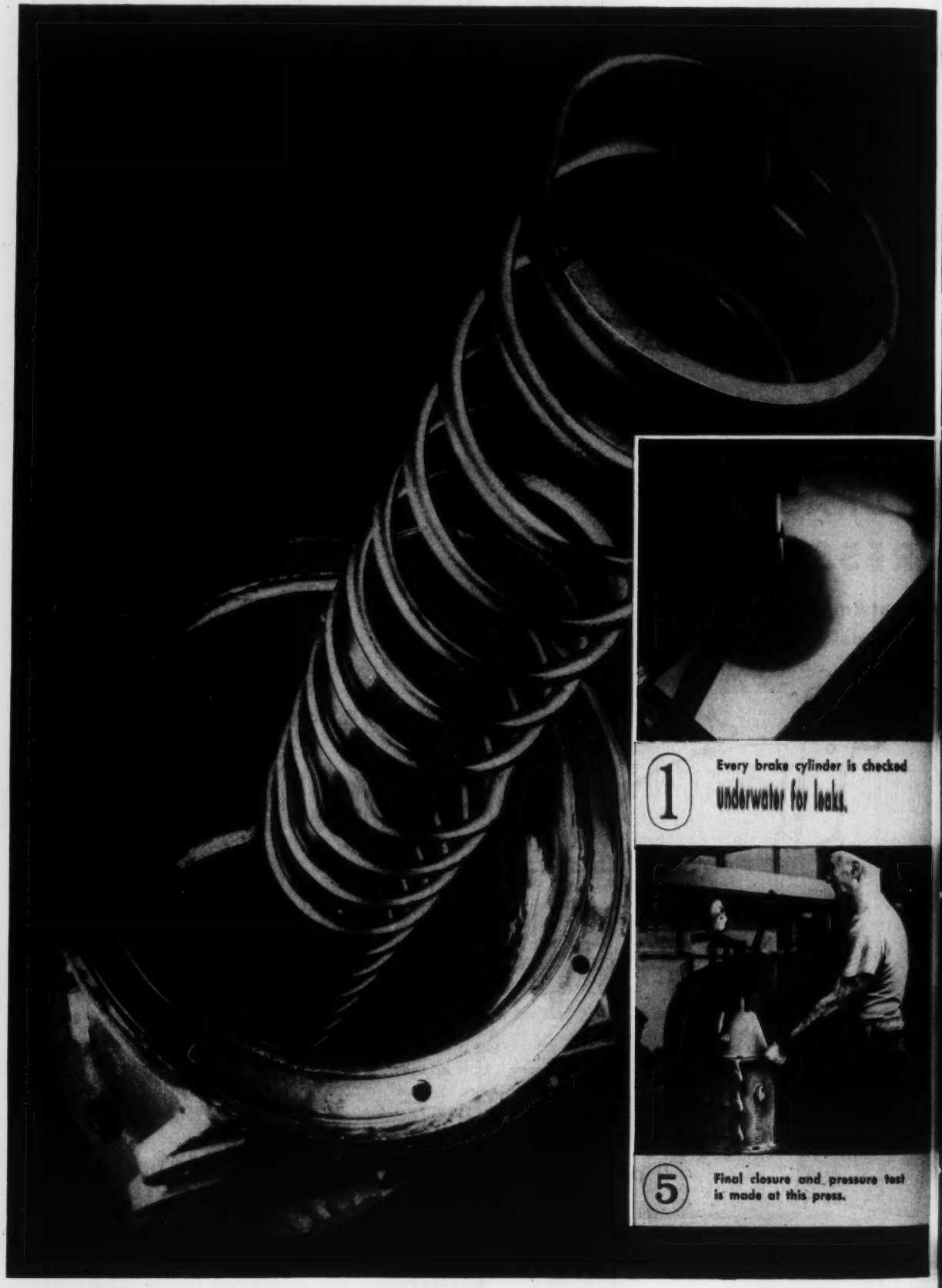
Miller

MILLER FLUID POWER DIVISION FLICK-REEDY CORP

2006 N. HAWTHORNE AVE. • MELROSE PARK, ILL.

AIR & HYDRAULIC CYLINDERS • BOOSTERS • ACCUMULATORS
COUNTERBALANCE CYLINDERS

Inside story of the most



1 Every brake cylinder is checked underwater for leaks.

5 Final closure and pressure test is made at this press.

famous brake in the world

Even schoolboys know the fabulous story of George Westinghouse, and how he accelerated developments of railroad transportation with his Westinghouse Automatic Air Brake.

Even if a train breaks in two, brakes are applied to *each* section to stop it.

Although Westinghouse Air Brake Company has made countless improvements in braking devices, the basic operating principles have prevailed since 1872. Original design of some parts is still followed today, that's how well they were designed in the first place.

A good example is the release spring, which retracts the brake cylinder piston when the brakes are released. American Steel & Wire has been supplying this spring for about 75 years. And although better steels and heat treatment are always being used, this original spring design has been operating over a 160° F. temperature range, stressed hundreds of times monthly, and is currently in service on over 2 *million* freight cars all over the world.

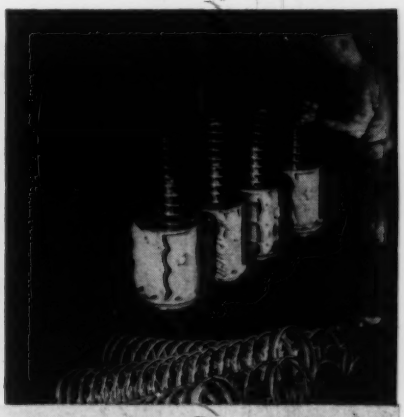
We are proud of our long association with Westinghouse Air Brake Company, maker of the most famous brake in the world, considered by many people to be one of the great inventions of our time.

AMERICAN STEEL & WIRE DIVISION, UNITED STATES STEEL, GENERAL OFFICES: CLEVELAND, OHIO
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO, PACIFIC COAST DISTRIBUTORS
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA., SOUTHERN DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS AMERICAN QUALITY SPRINGS

2 Piston assembly. Westinghouse Air Brake Company makes its own rubber parts.

3 After piston is inserted, workman lubricates the cylinder.



4 Spring inserting. The housing is machined high-density cast iron.

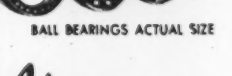
6 Cylinder at left is for freight cars, other is one of several used on a locomotive.

7 In position. Cylinders go three years between cleanings.

USS

UNITED STATES STEEL

Stuck? Got problems in design miniaturization that remind you of this? Send for the inside info on how over 500 types and sizes of MPB*s such as these will help to make things easier and easier and easier.


BALL BEARINGS ACTUAL SIZE

Snip coupon now!

MINIATURE PRECISION BEARINGS, INC., 3 PRECISION PARK, KEENE, N. H.

Send me without charge or obligation
( ) bi-monthly MPB ENGINEERING NEWS,
of MPB's in the field of_____
( ) My copy of new MPB Catalog,
( ) special data on use

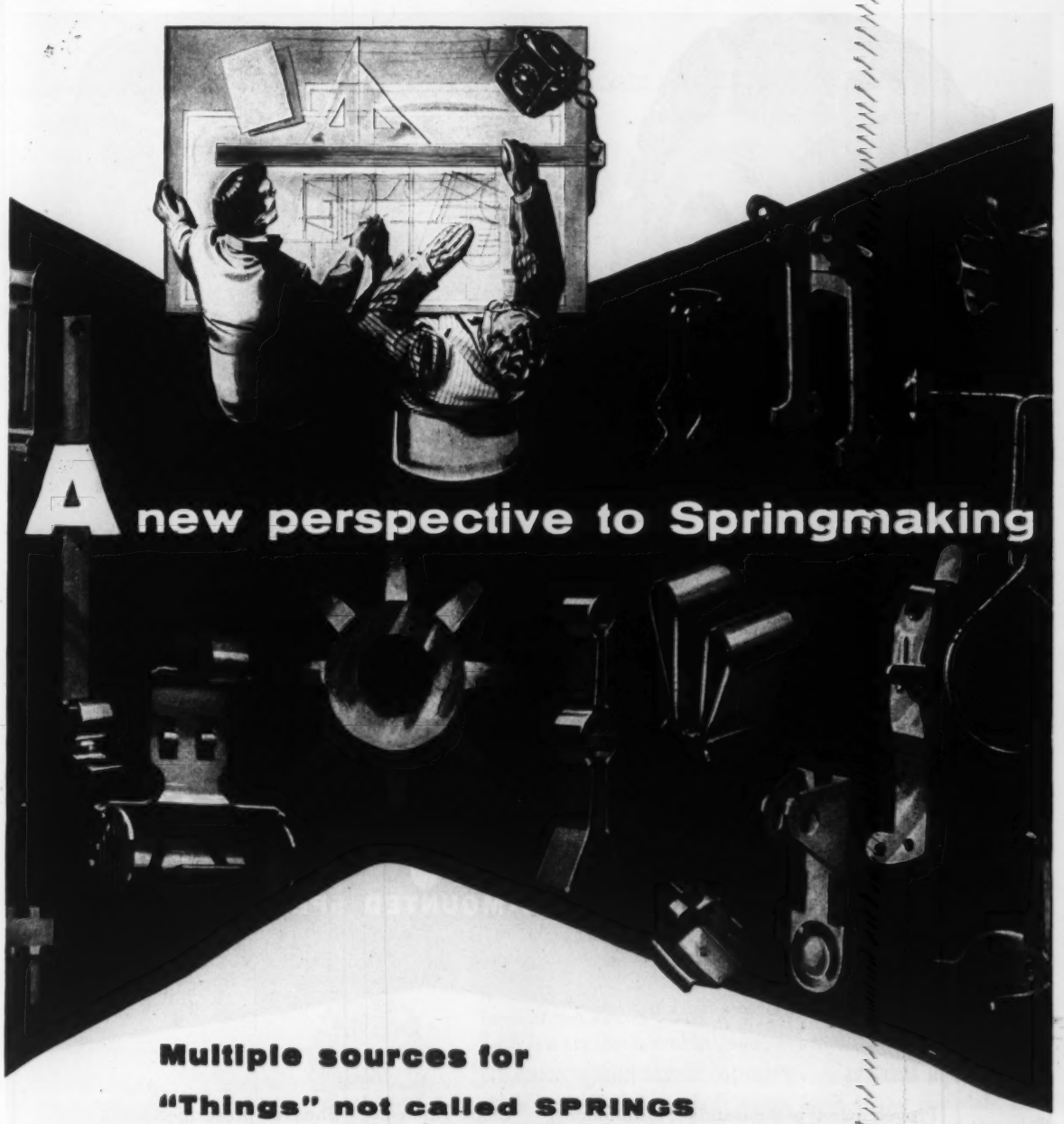
name title company

street city zone state

* MINIATURE PRECISION BEARINGS, INC., KEENE, N. H.

—ITEM 585—

For More Information Circle Item Number on Yellow Card—page 19



A new perspective to Springmaking

Multiple sources for "Things" not called SPRINGS

Yours to put to work . . . . our mechanical ingenuity and craftsmanship . . . . experienced in producing an infinite variety of metal parts in such fields as automation, communication, medical, electronics, safety devices, product development, etc. The capacity of ASC springmaking minds and machines is unlimited. Ask any Division to examine your sample or blueprint.

WALLACE BARNES COMPANY BRISTOL, CONNECTICUT

THE WILLIAM D. GIBSON COMPANY 1800 CLYBOURN AVE. CHICAGO 14

RAYMOND Manufacturing COMPANY CORRY, PENNSYLVANIA

BARNES-GIBSON-RAYMOND 40300 PLYMOUTH RD. PLYMOUTH, MICH.

B-G-R COOK PLANT ANN ARBOR MICHIGAN

DIVISIONS OF ASSOCIATED SPRING CORPORATION COAST TO COAST

SEABOARD Coil Spring Div. 15001 S. BROADWAY GARDENA, CALIF.

OHIO DIVISION 1825 EAST FIRST ST. DAYTON, OHIO

WALLACE BARNES COMPANY STATE FAIR BLVD. SYRACUSE 9 (Salina), N.Y.

MILWAUKEE DIVISION 341 E. ERIE ST. MILWAUKEE, WIS.

DUNBAR BROTHERS COMPANY BRISTOL, CONN.

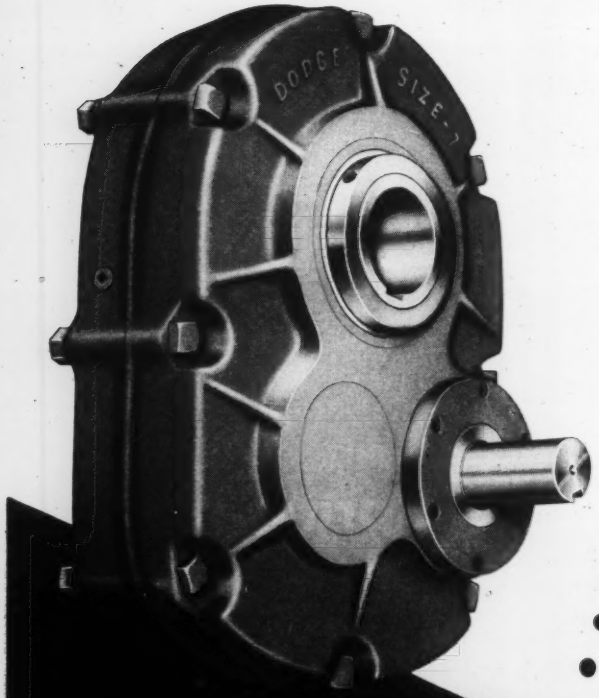
F. N. MANROSS AND SONS CO. BRISTOL CONNECTICUT

THE WALLACE BARNES CO., LTD. HAMILTON CANADA

Divisions of

ASSOCIATED SPRING CORPORATION

—ITEM 586—



97% EFFICIENCY

- NO FOUNDATION
- NO FLEXIBLE COUPLING
- NO SLIDING BASE
- NO LINING UP PROBLEM

—that's Torque-Arm

THE DODGE SHAFT-MOUNTED SPEED REDUCER

Proved in tens of thousands of installations, in all types of industry, this new and better kind of speed reducer delivers up to 97% efficiency . . . makes savings up to one-third!

Mounted directly on the driven shaft, the reducer is anchored by the Torque-Arm, fastened to any fixed object. No need for foundation, flexible coupling or sliding base. No lining up difficulties. Unit is driven through any V-belt drive. Stock Taper-Lock Sheaves prescribed for each job. Tri-Matic Overload Release and Backstop available if desired.

Dodge Torque-Arm is America's most complete line of shaft-mounted speed reducers — single and double reduction series—capacities from 1 hp to 60 hp; output speeds of 12 to 365 rpm. Sold from Distributors' stocks.

DODGE MANUFACTURING CORPORATION
3300 Union Street, Mishawaka, Indiana

Call the Transmissioneer, your local Dodge Distributor. He can give you valuable assistance on new, cost-saving methods. Look for his name under "Power Transmission Machinery" in your classified phone book, or write us.

DODGE
of Mishawaka, Ind.

—ITEM 587—
For More Information Circle Item Number on Yellow Card—page 19

What shape is a quality fastener?

Here is a handful of ELASTIC STOP® nuts. Each has ESNA's familiar red locking collar . . . is self-locking and vibration-proof. Each is a readily assembled, one-piece unit. Each provides positive protection against thread corrosion . . . prevents liquid seepage along bolts. Each is made from the finest of raw materials. Each is exactly controlled as to finished dimensions, class of thread fit and finish. Each is now in use on critical applications, with a record for uniform high quality that is unmatched.

Most of them are standard parts. Some originated as the result of a specific request for ESNA's help with an important fastening problem.

Isn't it logical to call on us with your next fastening problem?

ELASTIC STOP NUT CORPORATION OF AMERICA

ESNA TRADE MARK

ROLLPIN TRADEMARK

Elastic Stop Nut Corporation of America
Dept. N62-44, 2330 Vauxhall Road, Union, N. J.

Please send the following free fastening information:

☐ ELASTIC STOP nut bulletin

☐ Here is a drawing of our product. What self-locking fastener would you suggest?

Name _____ Title _____

Firm _____

Street _____

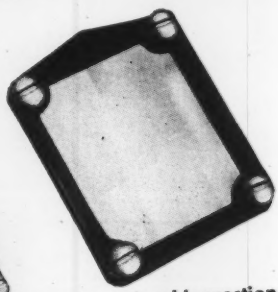
City _____ Zone _____ State _____

SQUARE D LIMIT SWITCHES WITH Features

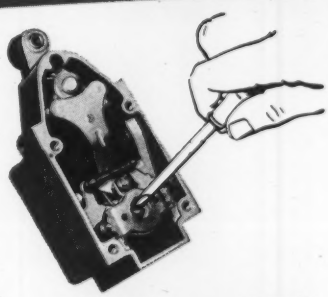
–TO THOSE WHO BUILD MACHINES

Square D limit switches have certain design features that warm the cockles of any machine builder's heart. You can spot the major ones in the panels below. Equally important is the customer's nod of approval when he sees the time-proven D nameplate on the limit switches that help control his new machine.

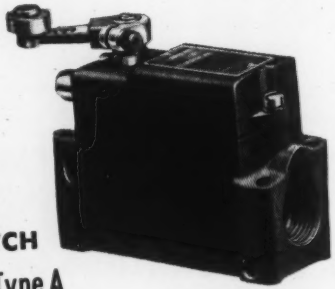
HEAVY DUTY
OIL-TIGHT LIMIT SWITCH
Class 9007 • Type T



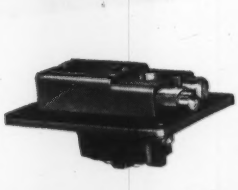
Instant visual inspection of mechanism through transparent plastic cover (optional). A tremendous time saver in multiple switch installations.



Eleven contact arrangements in one switch...and all you need to make the changes is a screwdriver!



SMALL
OIL-TIGHT LIMIT SWITCH
Class 9007 • Type A



This small precision limit switch is available in three forms—basic contact mechanism, flush mounting and surface mounting. Both flush and surface mounting switches are available with varying lengths of roller arms and with rollers of different types and sizes. Also push rod operated *(shown above)* and in single unit or duplex construction.

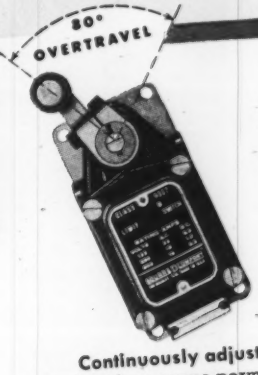
SQUARE D COMPANY

that Mean Plenty

...AND TO THOSE WHO BUY THEM

Just as you'd suspect, it's Square D's consistent performance and long life that appeals most to the men who buy and maintain the machines. But there are other advantages, too, having to do with versatility, easier installation and simpler maintenance. Some of the more important ones are illustrated below.

Simplified stocking because basic switches and a wide variety of lever arms are packaged separately. Moderate stock handles a multitude of combinations.



Continuously adjustable operating lever arms permit an infinite number of adjustments! Up to 80° overtravel reduces arm breakage.

Easy mounting and interchangeability through wide variety of base plates and side mounting holes.

Roller arms are available in a wide range of designs and lengths.

Write for Bulletin 9007 ... which gives the details of Square D's complete line of oil-tight limit switches. Address Square D Company, 4041 North Richards Street, Milwaukee 12, Wisconsin.

Everybody's Ahead with Square D!

THE LATEST NEWS ON SIMPLIFYING DESIGN

John Macadam, one of National's staff of applications engineers, displays example of the forming versatility of vulcanized fibre.

Versatile Vulcanized Fibre by National reduces cost of dies and molds and simplifies parts for fast assembly.

Today's big news in product design is *simplification* through the use of molded plastic parts. But molding may not be your best answer. *Formed fibre* is often a cheaper—and better—solution!

Look to National Vulcanized Fibre as an engineering material with these advantages:

Lower die or mold costs

Excellent forming qualities

Greater durability—toughness plus resilience

Good heat resistance and dimensional stability

Low material cost

National Vulcanized Fibre and its unique combination of mechanical and electrical properties suit this lightweight, low-cost material to hundreds of difficult applications. And National's generations of experience can always be tapped for answers to your problems.

The typical examples on this page show what can result when our skilled technicians apply versatile vulcanized fibre to your particular job. Consult your nearest National representative about your current materials problem—or write Wilmington, Delaware, Dept. G-4.

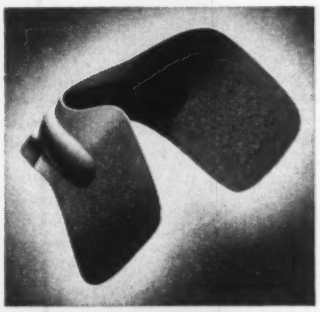
See us at Philadelphia—Design Engineering Show—May 14-17—Booth No. 212

NATIONAL VULCANIZED FIBRE CO.

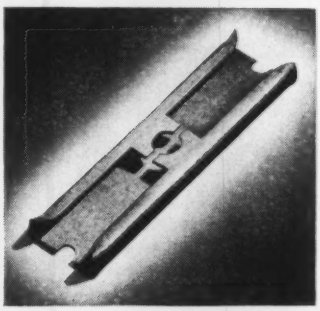
WILMINGTON 99, DELAWARE

In Canada: **National Fibre Company of Canada, Ltd.** • Toronto 3, Ont.

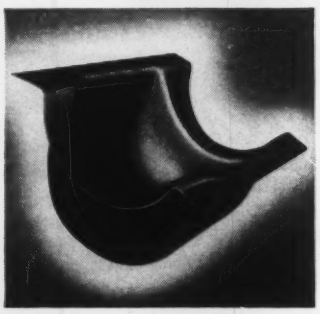
VULCANIZED FIBRE • PHENOLITE LAMINATED PLASTIC • PEERLESS INSULATION
KENNETT MATERIALS HANDLING RECEPTACLES • VUL-COT WASTEBASKETS
LESTERSHIRE TEXTILE BOBBINS • VULCOT PRODUCTS FOR THE HOME



Drawn and formed in one operation, the hip guard shown here possesses the resilience, toughness and shape retention that make vulcanized fibre the most used material for protective athletic equipment. Channel draw strengthens structure yet retains necessary spring. The piece is dipped, then baked with synthetic enamel for moisture protection and good appearance.



Punched, formed, scived and flared, this insulator component shows the successful solution of a difficult problem—boxing a channel on all four sides. In fabricating, the blank of vulcanized fibre was first cut to contour, after which the ends were scived, then formed into a box section and flared. This combination of operations makes the piece unusual.



Formed and deep drawn to a depth of 7 inches, this welder's helmet demonstrates the extreme workability of vulcanized fibre. Fabrication was by a single draw with an open bottom die—i.e., fibre was pulled in four different directions. Drawing depth and radii curve are about the maximum limit.

How can you afford ordinary gear type couplings when AJAX NEW 3-D DIHEDRALS HANDLE 3 DEGREE MISALIGNMENT at the same low price?

With ability to handle angular and offset misalignment...with minimum backlash... with perfected lubricant sealing...with long life,—Ajax Dihedral Couplings have made ordinary couplings obsolete. And now AJAX adds this new 3-D Self-aligning Dihedral Coupling at prices competitive with ordinary gear type couplings.

Features of the new Ajax 3-D Dihedral Coupling include:

- 3 degree misalignment capacity.
- Load is distributed at center of teeth at the point of greatest strength.
- More tooth strength is provided under misalignment than is possible with any other tooth shape.
- Exclusive Ajax Dihedral tooth design has less clearance than conventional gear type couplings.
- No end-of-tooth wear under misalignment. Johns-Manville "Clipper" seals keep lubricant in and foreign matter out.
- Compact overall size.
- Designed for NEMA motors with standard keys.
- Low prices competitive with ordinary gear type couplings.

Cut-away view of Ajax 3-D Dihedral Self-aligning Coupling showing arrangement of specially designed gears and location of lubrication seals.

AVAILABLE IN 5 SIZES

Write for new Catalog No. 60

Patented or Patents Pending in U.S.A. and foreign countries.

Friction Surfaces Need Parco Lubrite

Wear is a problem wherever there is sliding or rolling contact. Parco Lubrite controls wear on metal friction surfaces.

The phosphate coating produced by Parco Lubrite is nonmetallic, provides a separating layer of phosphate crystals that holds lubrication, prevents metal to metal contact during break-in, minimizes scoring and scuffing.

Parco Lubrite is used on shafts, gears, pistons, cylinder liners, valves, rings, and scores of other parts. The inexpensive, simple, quick process gives uniform high-quality results.

The friction surfaces of your product will be improved by Parco Lubrite. Full information is yours on request.

Bonderite, Bonderlube, Parco, Parco Lubrite—Reg. U.S. Pat. Off.

Since 1914—leader in the field

PARKER RUST PROOF COMPANY

2193 E. Milwaukee, Detroit 11, Michigan

BONDERITE	BONDERITE and BONDERLUBE	PARCO COMPOUND	PARCO LUBRITE	TROPICAL
corrosion resistant paint base	aids in cold forming of metals	rust resistant	wear resistant for friction surfaces	heavy duty maintenance paints since 1883

—ITEM 593—

For More Information Circle Item Number on Yellow Card—page 19

Don't overlook what you can't see

You can't always see what makes a gear-motor outstanding. It's the attention **paid to small design** details that makes the difference. Here are a few of the details that make the new Reliance Gearmotor **stand above the rest.**

FOOLPROOF METERMATIC motor bearing lubrication and oil bath gear lubrication for long-life protection against wear.

INDUCTION HARDENING of the tough alloy steel gears gives a perfect combination of wear resistance and strength.

SIMPLIFIED GEARING with few moving parts reduces friction losses and lessens chances of breakdown.

THRUST BEARINGS handle heavy overhung loads safely by placing strain on the frame instead of the shafts.

Find out the complete story for yourself— contact your Reliance representative or write for Bulletin E-2408.

REDUCE SPEED

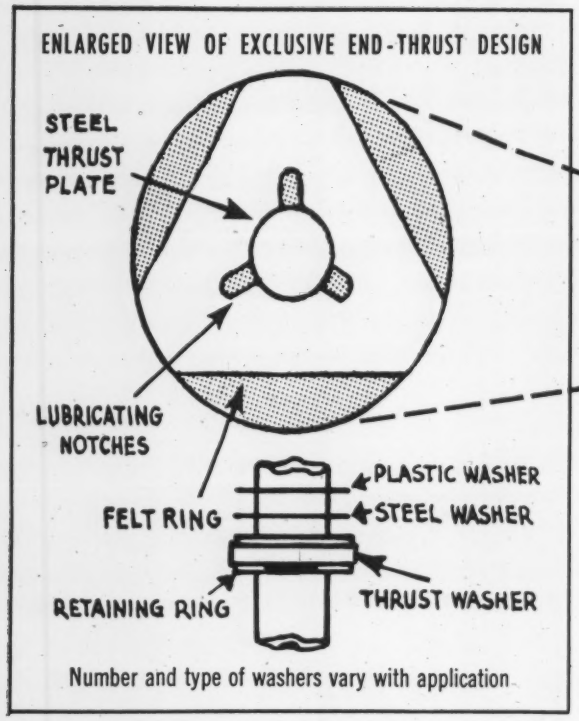
RELIANCE ELECTRIC AND ENGINEERING CO.

CLEVELAND 10, OHIO • OFFICES IN PRINCIPAL CITIES

Canadian Division: Welland, Ontario

Emerson-Electric engineering highlights

New, exclusive end-thrust design for vertical and shaded-pole, sleeve-bearing motors



Number and type of washers vary with application

Reduces wear and end play—minimizes starting failures and burnouts

Smooth, quiet operation and longer motor life result from the exclusive end-thrust design incorporated in Emerson-Electric sleeve-bearing motors, for thrust applications.

The face of the new-design steel thrust plate is provided with three slotted lubricating notches. In operation, the lubricant-saturated felt ring "bellies" up through the slots. This causes the felt-ring lubricant to be carried to the thrust surface. Continuous lubrication is thus assured—longer, noiseless operating life results.

This exclusive end-thrust feature is another Emerson-Electric engineering highlight. It illustrates once more the reason why Emerson-Electric motors have been the wise choice for power-driven equipment for more than 60 years.

Call on Emerson-Electric motor-drive specialists

The combined experience of Emerson Electric motor-drive specialists is available to designers and manufacturers of motor-driven appliances. This valuable "assist" from Emerson Electric can be profitably applied, whether you're designing or redesigning for performance and sales. Write for Bulletin No. M29. THE

EMERSON ELECTRIC MFG. CO.,
St. Louis 21, Mo.

Emerson-Electric of St. Louis • Since 1890

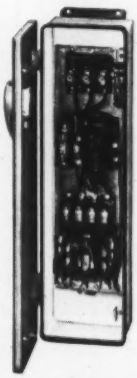
BRANCHES: NEW YORK 7, N. Y., 11 Park Place • CHICAGO 23, ILL., 1623 S. Pulaski Road • SYRACUSE, N. Y., 209 Oakley Drive
PHILADELPHIA (Secane), PA., 868 Quince Lane • DETROIT 7, MICH., 1375 E. Jefferson Ave. • CLEVELAND 16, OHIO, 1580 Rockland Ave.
LOS ANGELES 42, CALIF., 5415 York Blvd. • DAVENPORT, IOWA, 617 Brady Street • CINCINNATI 11, OHIO, 2917 Ratterman Ave.

A New Line

OF BULLETIN 712 COMBINATION STARTERS

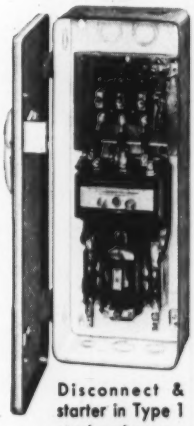
Allen-Bradley announces a modernization of its Bulletin 712 combination starters that should meet with the instant approval of plant "safety" organizations. The cover cannot be opened unless the operating lever is in the "off" position; also the movable disconnect contacts are **plainly visible** when this switch is "open." A welded or sticking contact can be detected instantly. The new operating lever contains a concealed latch pin which permits the maintenance man to open the cabinet without opening the disconnect and stopping the motor. Disconnect switch can be padlocked with three locks—in the open position. It can be arranged for padlocking in running position.

SIZE 1



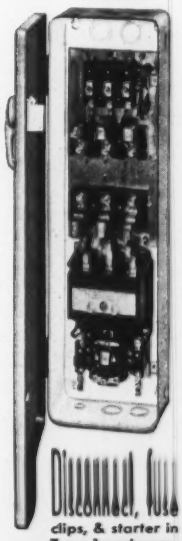
Disconnect, transformer, & starter in Type 1 cabinet.

SIZE 2



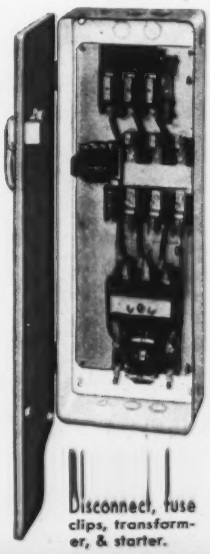
Disconnect & starter in Type 1 steel enclosure.

SIZE 2



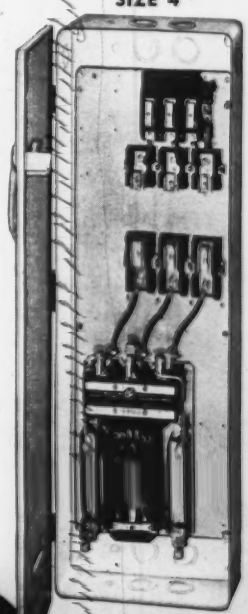
Disconnect, fuse clips, & starter in Type 1 enclosure.

SIZE 3



Disconnect, fuse clips, transformer, & starter.

SIZE 4



Disconnect, fuse clips, & starter in Type 1 enclosure.

Allen-Bradley Co.
1316 S. Second St.
Milwaukee 4, Wis.

In Canada—
Allen-Bradley Canada Ltd.
Galt, Ont.

ALLEN-BRADLEY

TROUBLE FREE MOTOR CONTROLS

A-B Quality

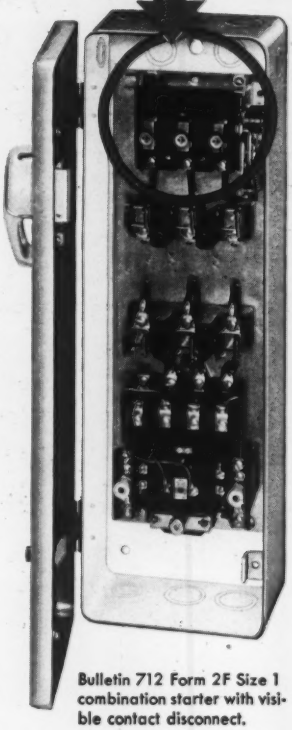
4-56-MR

NEW! The first disconnect switch with movable contacts that are plainly visible in the OFF position

Allen-Bradley has finally succeeded in producing a disconnect switch, which removes all doubt whether the movable contacts are in the "open" or "closed" position. When in the "open" position, they are plainly visible—as open; when in the "closed" position, they are dropped—out of sight in the arc hood.

The moving, double break contacts of the new disconnect (shown in yellow above) move horizontally in individual arc chambers. When the disconnect is CLOSED, the moving contacts are DOWN in the arc chambers. In the OPEN position the moving contacts are UP in plain view, as shown in the colored illustration directly above.

If a contact should stick or weld, it will fail to rise to its "open" position and thereby indicate that the respective "link" remains closed—a plainly visible warning signal to the maintenance man.



Bulletin 712 Form 2F Size 1 combination starter with visible contact disconnect.

A unique feature of the new line are the interlocks built into the disconnect lever.

First—the disconnect lever is interlocked with the door latch so that the door cannot be opened unless the lever is in the OFF position. This assures that the starter is "dead" when the cabinet is open and is safe to inspect.

Second—the disconnect lever has a concealed release pin used only by authorized persons for opening the cabinet door, if needed, without shutting down the motor.

Standard operating lever permits use of one to three padlocks to lock in "off" position, but also can very simply be changed to permit padlocking in "on" position.

These new Bulletin 712 combination starters are available in NEMA Type 1, 4, 7, 9, and 12 enclosures. They are listed from 1 to 100 hp, 220 v; 200 hp, 440-550 v.

Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis. • In Canada—Allen-Bradley Canada Ltd., Galt, Ont.

A-B

ALLEN-BRADLEY

QUALITY

4-56-MR

TORRINGTON *TAPERED ROLLER* BEARINGS

Accurately caged... to cut your costs!

The one-piece, cast-bronze cage you see above is one of the reasons why TORRINGTON Roller Bearings give long, low-cost service. Note the individual roller retainment, for example. This helps keep the rollers thoroughly lubricated at all times. Race surface inspection is simplified. The machined pads in each roller pocket make sure the rollers are guided accurately at the pitch line. All this to minimize wear... lengthen bearing life.

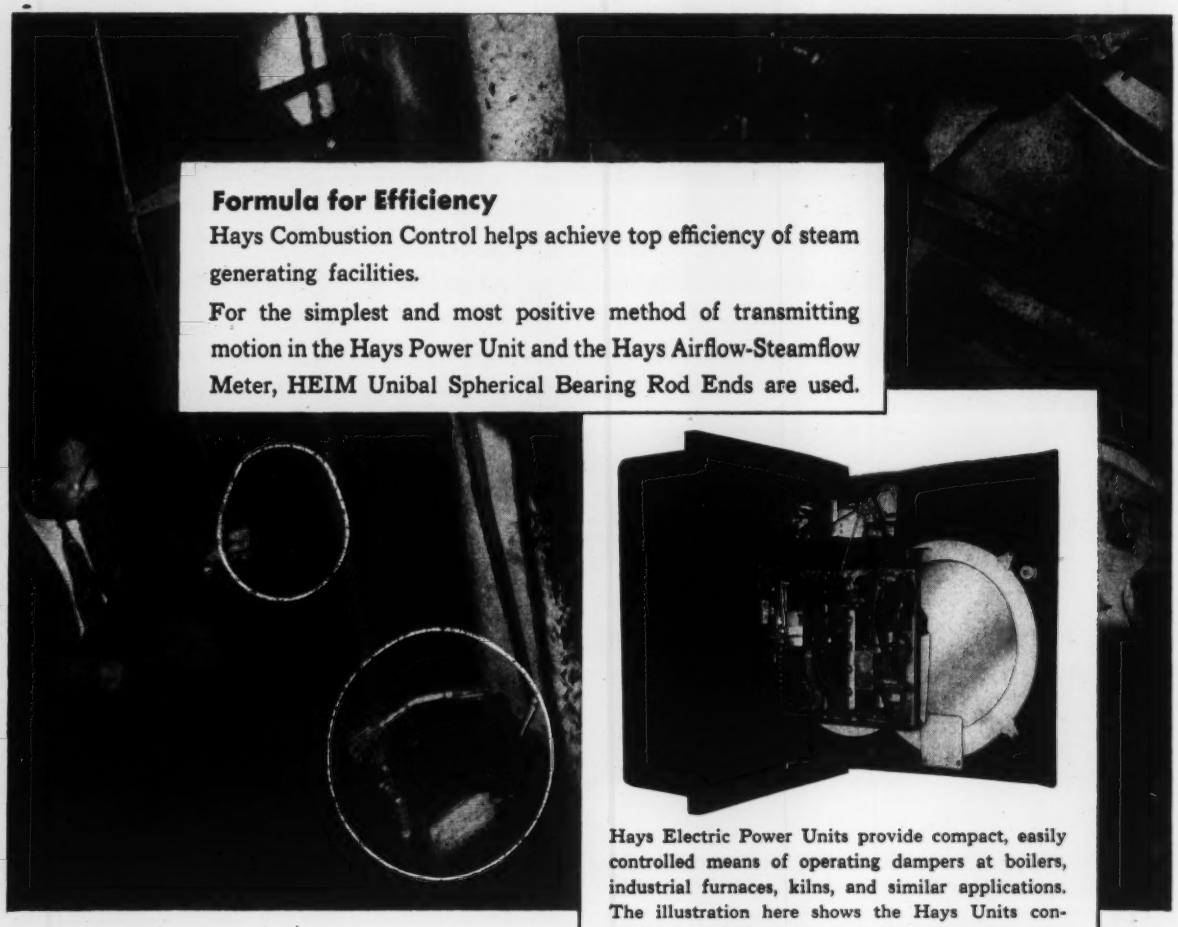
Yes, TORRINGTON Roller Bearings cut your costs. They're made of the finest bearing quality steel available, heat treated by the most modern methods. No wonder they're so rugged... so dependable. Specify TORRINGTON *Tapered* or *Cylindrical* Roller Bearings for heavy loads and low maintenance.

THE TORRINGTON COMPANY
South Bend 21, Ind. • Torrington, Conn.
District offices and distributors in principal cities of United States and Canada

90th ANNIVERSARY 1865-1955

TORRINGTON BEARINGS

Spherical Roller • Tapered Roller • Cylindrical Roller
Needle • Ball • Needle Rollers



Formula for Efficiency

Hays Combustion Control helps achieve top efficiency of steam generating facilities.

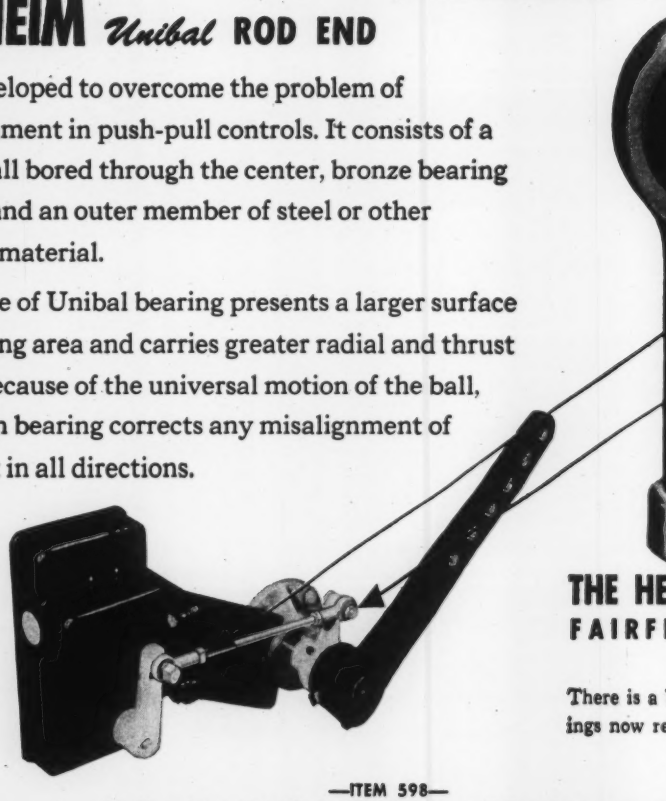
For the simplest and most positive method of transmitting motion in the Hays Power Unit and the Hays Airflow-Steamflow Meter, HEIM Unibal Spherical Bearing Rod Ends are used.

Hays Electric Power Units provide compact, easily controlled means of operating dampers at boilers, industrial furnaces, kilns, and similar applications. The illustration here shows the Hays Units controlling the fuel feed on two Pulverizers.

The HEIM *Unibal* ROD END

was developed to overcome the problem of misalignment in push-pull controls. It consists of a single ball bored through the center, bronze bearing inserts, and an outer member of steel or other suitable material.

This type of Unibal bearing presents a larger surface supporting area and carries greater radial and thrust loads. Because of the universal motion of the ball, the Heim bearing corrects any misalignment of the shaft in all directions.



HEIM
ROD END

THE HEIM COMPANY
FAIRFIELD, CONN.

There is a brand new catalog of Heim bearings now ready. Please write for your copy.

—ITEM 598—

REVERE *Aluminum* and the '56 PACKARD *Royal Look*

It is fitting that the new Packard, a car of royal distinction, should face the world with a grille that has the look of gold. It is, in fact, of gold-anodized aluminum,* so authentic in appearance that it cannot be told, by the eye alone, from 18 karat gold.

Here is far more than another advance in motor car styling. For this grille of Revere Aluminum not only lightens the front end but is strong and rust-proof, with a finish that will not tarnish or peel. Aluminum is the only metal that lends itself so perfectly to finishing of this type. The hues of the rainbow and more are attainable . . . but the aluminum itself must be right. The choice of Revere Aluminum for this exacting function is a further indication of how thoroughly Revere knows its A B C's in metals— A for Aluminum, B for Brass, C for Copper.

If you are using aluminum or planning to, you can turn to Revere with confidence for sheet, tube, pipe, extruded shapes, bus conductors, forgings and foil. Why not call the nearest Revere office now? In all principal cities. Revere Copper and Brass Incorporated. Founded by Paul Revere in 1801.

REVERE Offices: 230 Park Avenue, New York 17, N. Y.

*Grille is of Revere Aluminum Sheet. Before anodizing to give it the gold color and protective coating, it is skilfully perforated by The Harrington & King Perforating Co. of Chicago and accurately formed by Automotive Stamping & Manufacturing Co. of Detroit.

—ITEM 599—

A Formsprag Clutch can simplify the functioning of your design

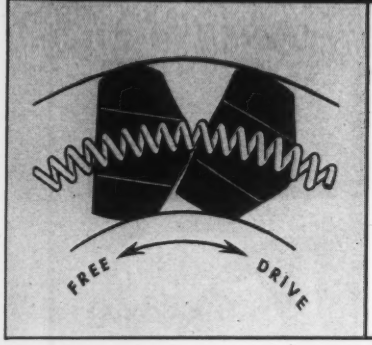
William T. Cherry, Mgr., Formsprag Application Engineering Dept.

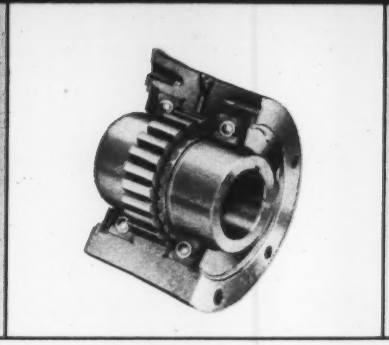
Designers are constantly finding ways to simplify the design of their products by utilizing Formsprag's higher torque capacity and precision. Over-running, indexing, and backstopping applications are almost unlimited.

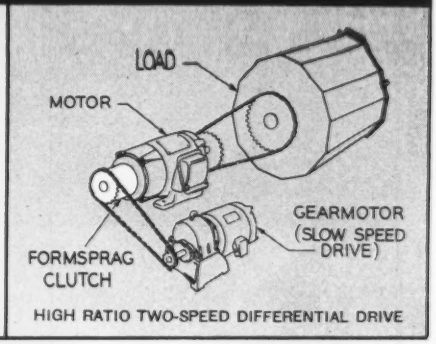
The modern, patented design of Formsprag Clutches is the secret. Each clutch—designed with utmost simplicity—offers the highest possible torque capacity in an extremely small area. And, you get rugged, precision performance with long life.

The next time you're thinking of maximum clutch efficiency for your product—remember these principles about Formsprag Clutches:

How Formsprag's simple, precision design works for you





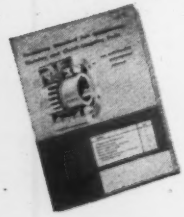


HIGH RATIO TWO-SPEED DIFFERENTIAL DRIVE

Sprags used in Formsprag Clutches are highly developed, precision wedges of hardened alloy steel. Due to the sprag's design, an unusually high amount of torque is delivered from one concentric race to the other. When torque is applied, the sprags are instantaneously engaged. When torque is removed, the sprags release instantaneously.

Basic construction of the Formsprag Clutch is simple. A full complement of sprags is inserted between inner and outer concentric races. Contact with both race surfaces is maintained by energizing springs. Formsprag construction allows more sprags to be inserted in a smaller area than other clutch designs. Result: greater torque capacity in a smaller clutch.

Here is a typical over-running arrangement on a two-speed drive: The clutch transmits power during the low speed cycle while the high speed motor acts as a countershaft and transmits power to the load. During the high speed cycle, the over-running clutch permits the low speed motor to be over-run. This arrangement is particularly economical and efficient where the speed differential required is too great for a two-speed motor.



Formsprag's engineering department has solved literally thousands of clutch application problems—using either standard or specially designed clutches. For further information, send for this informative eight-page brochure or contact Formsprag direct.

Distributors in Principal Cities

FORMSPRAG *Company*

23603 Hoover Road, Van Dyke, Michigan

World's Largest Exclusive Manufacturers of Over-Running Clutches

A7-48

—ITEM 600—

For More Information Circle Item Number on Yellow Card—page 19

DESIGNING WITH ALUMINUM

This is one of a series of information sheets which discuss the properties of aluminum and its alloys with relation to design. Extra or missing copies of the series will be supplied on request. Address: Advertising Department, Kaiser Aluminum & Chemical Sales, Inc., 1924 Broadway, Oakland 12, California.

NO. 18

Note—This article contains completely up-to-date information. It replaces your old sheet No. 9.

PROPERTIES AND CHARACTERISTICS OF ALUMINUM CASTING ALLOYS

CHOOSING the proper aluminum casting alloy and heat-treatment requires a complete knowledge of the service conditions of the part under consideration. The alloys, heat treatments and various casting methods in common use must also be understood.

There are over thirty recognized casting alloys, with as many as five different heat-treatment possibilities for some. This results in a large number of choices from which to satisfy individual requirements. Because of these many alloy and heat-treatment combinations the possible range of typical mechanical properties varies widely.

Frequently, commercial castings do not have critical service requirements, and in such cases the foundryman should be consulted to ascertain the most economical alloy and production method which will do the job.

However, in most instances castings are designed for maximum efficiency, and in such cases, the alloy and heat treatment must be carefully selected from those available. In doing this, the designer, with his greater knowledge of the service requirements for the casting, must confine the choice of alloys to those which provide the necessary properties. He must then be guided by the foundryman in the final choice, as the alloy which looks best in the tables may have some production characteristics which would make it less desirable on an overall basis than other eligible alloys. The foundryman is in the best position to advise on such factors as availability, relative ingot costs, production costs and reproducibility of results. When this is coordinated with the designer's knowledge of service requirements such as strength, hardness, corrosion resistance, impact strength and machinability, the best possible selection will result.

As a result of this coordination, changes from initial design may be indicated which will improve design efficiency, or lower production costs, or both. For instance, a casting having sound design from every other standpoint may have a size or shape pointing to problems of distortion in heat treating which could be minimized through design changes.

Factors to Consider

The production and service requirements have a large bearing on the casting method, as do size and shape of part. For example, castings required in fairly large numbers, should be made either by permanent mold or die casting process, provided the size and design features of casting and available alloys are suitable.

The sand casting process is usually confined to producing parts required in small quantities, those having hollow cavities and complex arrangement of ribs, pockets, etc., and to those whose size makes them unsuited for casting in metal molds. In many cases it will be advantageous to redesign a part to make it adaptable for production by either permanent mold or die casting method. Sand casting usually requires minimum tooling charge, but unit price of castings and the finished part is high. Permanent molding and die casting involves higher tooling charge, but unit price is lower, particularly for longer runs. Die castings are the extreme, usually involving highest tooling charge and lowest piece price on large quantities.

Once the casting method is determined, the alloy choice is narrowed down appreciably.

Next to be considered are the service requirements. If high strength is necessary, that ordinarily eliminates the non-heat-treatable alloys when using an efficient design. This can be further and rapidly narrowed down when the remaining requirements such as leak tightness, corrosion resistance, machinability and others are considered.

In some instances, one certain property may be required to the maximum degree—for example, highest possible yield strength. This immediately narrows down the alloy and heat treatment choice as well as casting method to a possible one or two, and bigger compromises will have to be made for the other requirements, particularly ductility.

In other cases the large size and shape of a casting may not permit the use of a "solution heat-treatment," but will limit it to use of a "straight aging treatment" taking place in approximate temperature range of 300°F to 500°F, or to no treatment at all, thereby sacrificing, to a degree, some of the mechanical properties and slightly decreasing machinability.

The reason for this limitation is the fact that the first half of a solution heat-treatment takes place at a temperature ranging between 930°F to 1,000°F, followed by rapid quench in water. At those temperatures, the mechanical strength of aluminum is practically zero and therefore large unsupported areas of the casting, or the whole casting at times, may sag or distort from its own weight. Sometimes the size and shape of part are such that it can withstand the effects of the high temperatures but cannot be quenched without danger of warping or cracking.

Die castings are always used in the as-cast condition, which limits the choice to one of alloy selection only.

To assist the designer in becoming familiar with the various casting processes, mechanical properties, and physical properties we refer him to these tables on the following pages:

Table #1—Typical Mechanical Properties of Aluminum Sand Castings

Table #2—Typical Mechanical Properties of Aluminum Permanent Mold Castings

Table #3—Typical Mechanical Properties of Aluminum Die Castings

Table #4—Alloy Selection Guide

Sand casting, permanent mold casting, and die casting are the more widely used production methods. However, in special cases the part may be produced more efficiently by other methods such as shell molding, plaster molding, investment casting or centrifugal casting.

CONTINUED ON NEXT PAGE ➡

SAND CASTING ALLOYS—TABLE 1

Alloy	H. T.[3]	Typical Mechanical Properties[1]					Casting and Service Characteristics[2]						
		Tensile Strength psi	Yield Strength psi	Elongation Per Cent in 2"	Hardness Brinnell 10/500	Fatigue psi	Feeding Ability	Pressure Tightness	Hot-Shortness	General Castability	Machinability	Corrosion Resistance	Weldability[5]
43	AC	19,000	8,000	8.0	40	6,500	E	E	SL	E	F	VG	E
108	AC	21,000	14,000	2.5	55	8,000	VG	VG	MIN	VG	G	G	VG
122	T2	27,000	20,000	1.0	80	9,500	G	G	MOD	G	E	F	F
122	T61	41,000	40,000	(6)	115	8,500	G	G	MOD	G	E	F	F
142	T21	27,000	18,000	1.0	70	6,500	G	F	AP	F	VG	F	F
142	T571	32,000	28,000	.5	85	8,000	G	F	AP	F	VG	F	F
142	T77	28,000	25,000	2.0	75	9,500	G	F	AP	F	VG	F	F
195	T4[4]	32,000	16,000	8.5	60	6,000	G	G	AP	F	G	G	F
195	T6	36,000	24,000	5.0	75	6,500	G	G	AP	F	VG	G	F
195	T62	40,000	30,000	2.0	90	7,000	G	G	AP	F	E	G	F
212	AC	23,000	14,000	2.0	65	8,000	G	G	MOD	G	E	F	G
214	AC	25,000	12,000	9.0	50	5,500	F	F	MOD	F	E	E	G
B214	AC	20,000	13,000	2.0	50	.....	F	F	MOD	G	E	E	G
F214	AC	21,000	12,000	3.0	50	.....	F	F	MOD	F	E	E	G
220	T4	46,000	25,000	14.0	75	7,000	F	F	MOD	F	E	E	F
319	AC	27,000	18,000	2.0	70	10,000	E	E	SL	E	G	G	G
319	T6	36,000	24,000	2.0	80	10,000	E	E	SL	E	G	G	G
355	T51	28,000	23,000	1.5	65	7,000	E	E	SL	E	E	VG	VG
355	T6	35,000	25,000	2.5	80	8,500	E	E	SL	E	E	VG	VG
355	T61	39,000	35,000	1.0	90	.....	E	E	SL	E	E	VG	VG
355	T7	38,000	36,000	0.5	85	8,500	E	E	SL	E	E	VG	VG
355	T71	35,000	29,000	1.5	75	10,000	E	E	SL	E	G	VG	VG
356	T51	25,000	20,000	2.0	60	7,500	E	E	SL	E	G	E	VG
356	T6	33,000	24,000	4.0	70	8,000	E	E	SL	E	G	E	VG
356	T7	34,000	30,000	2.0	75	.....	E	E	SL	E	E	E	VG
356	T71	28,000	21,000	4.5	60	.....	E	E	SL	E	G	E	VG

NOTES:

1. Properties determined on standard tensile test bars cast under favorable conditions and properly heat-treated, when applicable.
2. Ratings: E, excellent; VG, very good; G, good; F, fair—apply to all castings and service characteristics except Hot-Shortness; AP, appreciable; MOD, moderate; MIN, minor; SL, slight.
3. AC, as cast.
4. On standing at room temperature for several weeks, properties approach those of T6 condition.
5. Weld before heat-treating, using appropriate filler rod.
6. Less than 0.5% elongation.

PERMANENT MOLD CASTING ALLOYS—TABLE 2

Alloy	H. T.[3]	Typical Mechanical Properties[1]					Casting and Service Characteristics[2]						
		Tensile Strength psi	Yield Strength psi	Elongation Per Cent in 2"	Hardness Brinnell 10/500	Fatigue psi	Feeding Ability	Pressure Tightness	Hot-Shortness	General Castability	Machinability	Corrosion Resistance	Weldability[5]
43	AC	23,000	9,000	10.0	45	.....	VG	E	SL	E	F	VG	E
A108	AC	28,000	16,000	2.0	70	.....	VG	VG	MIN	VG	G	G	VG
122	T52	35,000	31,000	1.0	100	.....	G	G	MOD	G	E	F	F
122	T551	37,000	35,000	.....	115	8,500	G	G	MOD	G	E	F	F
122	T65	48,000	36,000	.....	140	9,000	G	G	MOD	G	E	F	F
A132	T551	36,000	28,000	.5	105	13,500	G	VG	MIN	G	F	G	G
A132	T65	47,000	43,000	.5	125	.....	G	VG	MIN	G	F	G	G
D132	T5	36,000	28,000	1.0	105	13,500	VG	VG	MIN	VG	G	F	G
138	AC	30,000	24,000	1.5	100	.....	.....	G	MIN	F	G	.....	.....
142	T571	40,000	34,000	1.0	105	10,500	F	F	AP	F	VG	G	F
142	T61	47,000	42,000	.5	110	9,500	F	F	AP	F	VG	G	F
B195	T4[4]	37,000	19,000	9.0	75	9,500	G	G	MOD	G	G	G	G
B195	T6	40,000	26,000	5.0	90	10,000	G	G	MOD	G	G	G	G
B195	T7	39,000	20,000	4.5	80	9,000	G	G	MOD	G	G	G	G
A214	AC	27,000	16,000	7.0	60	.....	F	F	AP	F	E	E	G
319	AC	34,000	19,000	2.5	85	.....	E	E	SL	E	G	G	G
319	T6	40,000	27,000	3.0	95	.....	E	E	SL	E	G	G	G
355	T51	30,000	24,000	2.0	75	.....	E	E	SL	E	VG	VG	VG
355	T6	43,000	27,000	4.0	90	10,000	E	E	SL	E	VG	VG	VG
355	T62	45,000	40,000	1.5	105	10,000	E	E	SL	E	E	VG	VG
355	T7	40,000	30,000	2.0	85	10,000	E	E	SL	E	VG	VG	VG
355	T71	36,000	31,000	3.0	85	10,000	E	E	SL	E	VG	VG	VG
356	T6	40,000	27,000	5.0	90	13,000	E	E	SL	E	G	E	VG
356	T7	33,000	24,000	5.0	70	11,000	E	E	SL	E	G	E	VG
363	AC	35,000	23,000	2.7	85	.....	E	VG	SL	E	E	G	E
363	T6	48,000	28,000	6.5	90	.....	E	VG	SL	E	E	VG	E
750	T5	20,000	8,500	10.0	45	9,000	.....	.....	.....	.....	E	.....	.....

NOTES:

1. Properties determined on standard tensile test bars cast under favorable conditions and properly heat-treated, when applicable.
2. Ratings: E, excellent; VG, very good; G, good; F, fair—apply to all castings and service characteristics except Hot-Shortness; AP, appreciable; MOD, moderate; MIN, minor; SL, slight.
3. AC, as cast.
4. On standing at room temperature for several weeks, properties approach those of T6 condition.
5. Weld before heat-treating, using appropriate filler rod.

DIE CASTING ALLOYS—TABLE 3

Alloy	Condition[3]	Typical Mechanical Properties[1]					Casting and Service Characteristics[2]					
		Tensile Strength psi	Yield Strength psi	Elongation Per Cent in 2"	Hardness Brinnell 10/500	Fatigue psi	Mold Filling Capacity	Hot-Shortness	Die Solder Tendency	Machinability	Corrosion Resistance	Weldability
13	AC	39,000	21,000	2.0	.....	19,000	E	VL	E	F	VG	not
A 13	AC	35,000	16,000	3.5	.....	.....	VG	VL	VG	F	VG	recom-
43	AC	30,000	16,000	9.0	.....	17,000	G	MIN	F	F	VG	mended
218	AC	45,000	27,000	8.0	.....	23,000	F	AP	F	E	E	"
360	AC	44,000	27,000	3.0	.....	19,000	E	VL	G	F	G	"
A360[4]	AC	41,000	23,000	5.0	.....	18,000	E	VL	G	F	E	"
380	AC	45,000	26,000	2.0	.....	20,000	E	MOD	E	G	G	"
A380[4]	AC	46,000	25,000	3.0	.....	19,000	E	MOD	E	G	G	"
384	AC	46,000	27,000	1.0	.....	21,000	E	MOD	E	G	G	"

NOTES:

1. Properties determined from standard test bars cast under favorable conditions.
2. Ratings: E, excellent; VG, very good; F, fair—apply to all castings and service characteristics except "hot-shortness"; AP, MOD, MIN, VL apply to "hot-shortness" only.
3. As cast.
4. In A360 and A380, the iron content is controlled more closely than in 360 and 380 alloys.

SELECTION GUIDE—TABLE 4

Major Property Wanted	Sand Cast	Perm. Mold	Die Cast
General purpose—	43	43	13
Low strength	108	A108	A 13
arranged in order of decreasing	212	A214	43
castability	214		
General purpose—	355-T6	355-T6	380
Heat-treated[1]	356-T6	356-T6	A380
good balance of all properties	319-T6	319-T6	360
for most applications	195-T6	B195-T6	A360
Best castability for complex	43	43	A360; 360
castings with thin sections—	319	319	A 13; 13
arranged in order of decreasing	356	356	43
castability	108	M108	
	355	355	
High ductility and **shock**	220-T4	A214	218
resistance arranged in order	195-T4	B195-T4	A360
of decreasing properties	214[2]	356-T6	43
	356-T6	363-T6	
	319	319	
	43	43	
Pressure tight—Low stressed	43	43	A360
	108	A108	A 13
	319	319	43
Pressure tight—High stressed	356	356	A360
	355	355	
	319	319	
		363	

Major Property Wanted	Sand Cast	Perm. Mold	Die Cast
Corrosion Resistance	43	43	218
	214	A214	A360
	220	356	
	356	355	
	355	319	
	319	363	
Ornamental and Architectural	43	43	43
Applications—also food han-	214[2]	A214[2]	218[1]
dling, dairy equipment, cooking	B214[2]		
utensils and marine fittings	F214[2]		
Piston Alloys—good properties	122	122	384
at operating temperatures	142	A132	85
		D132	
		142	
Other alloys having good proper-	214	138	13
ties at moderate temperatures		A214	360
Good machinability—	122	122	218[1]
Heat-treated castings machine	212	355	380
better than those in as-cast	214	363	A380
condition, and generally those	B214	A214	
having highest hardness ma-	F214	A108	
chine better than the softer	220-T4	319	
ones in any one alloy	195		
	319		

NOTES:

1. Except die castings.
2. These alloys take anodized finish without appreciable discoloration.

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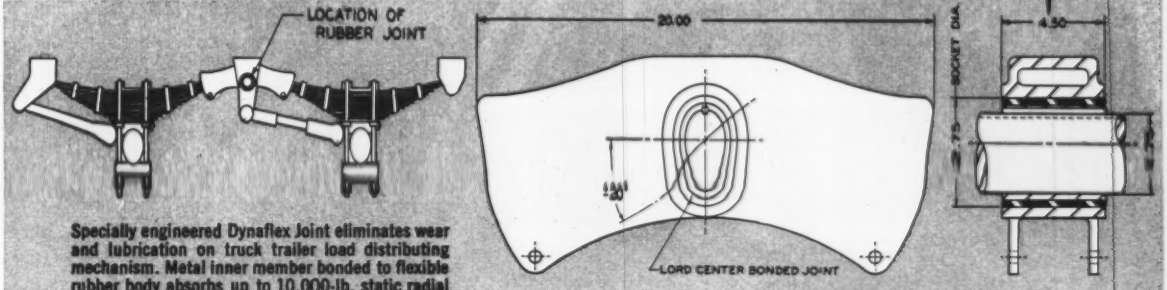

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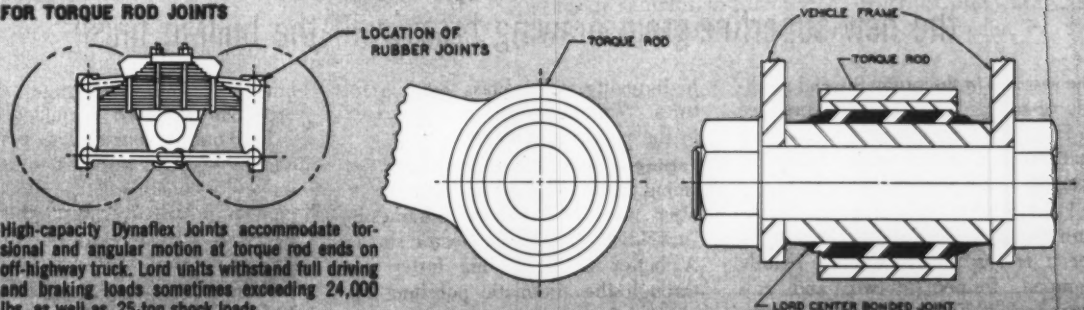

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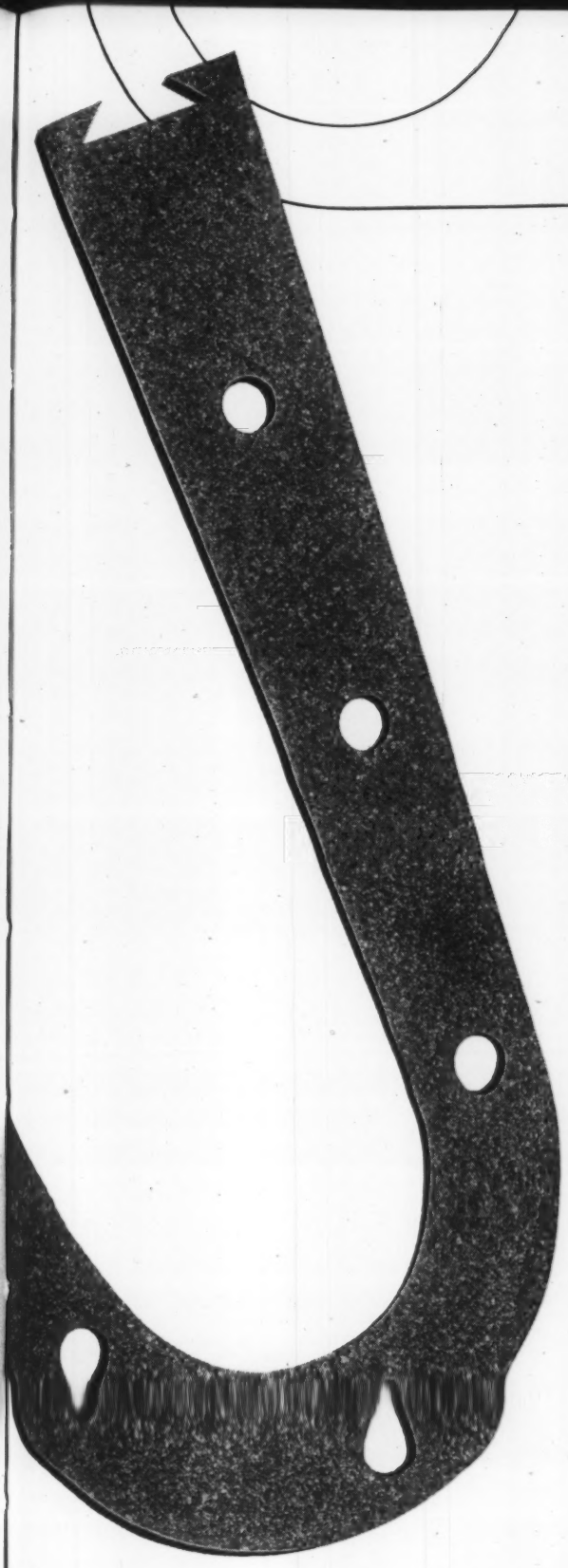

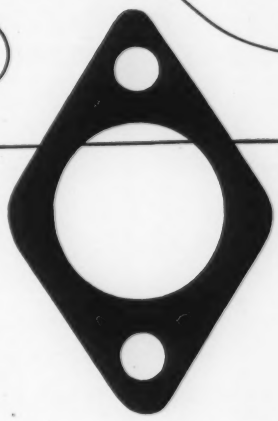

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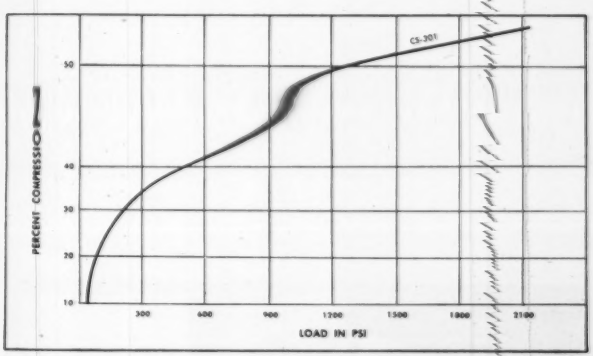
If you'd like more information about CS-301 Accopac, write for samples and data sheet to Armstrong Cork Company, Industrial Div., 7004 Dean St., Lancaster, Pa.



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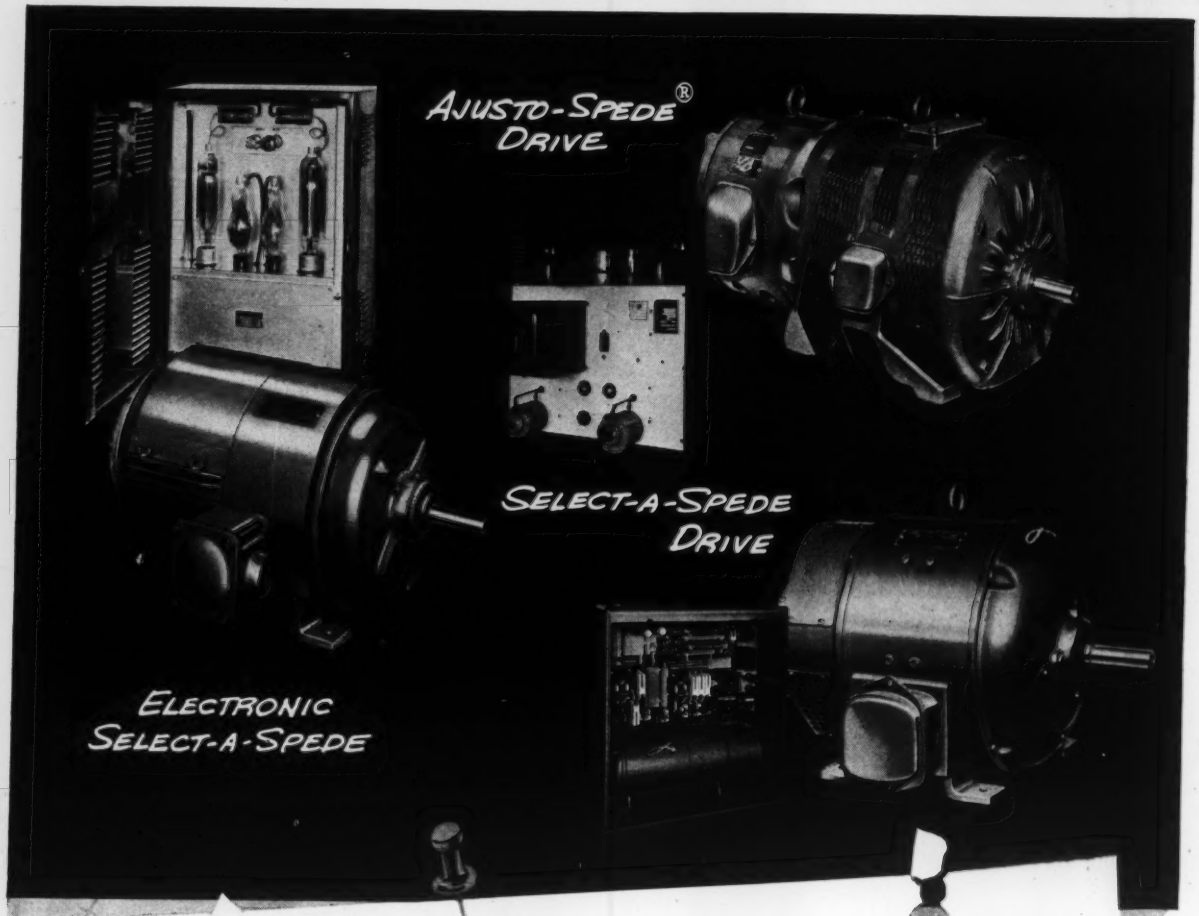

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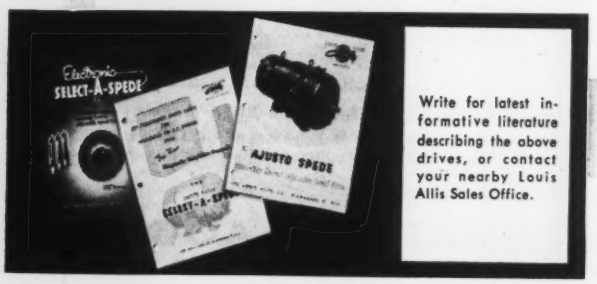

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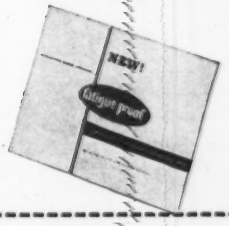

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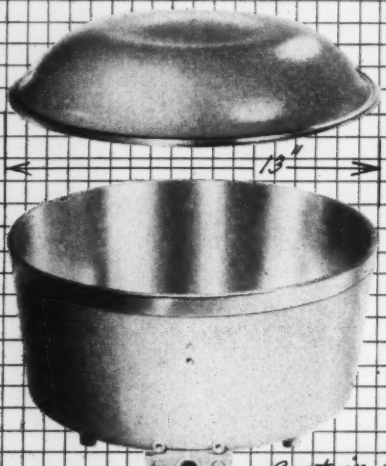

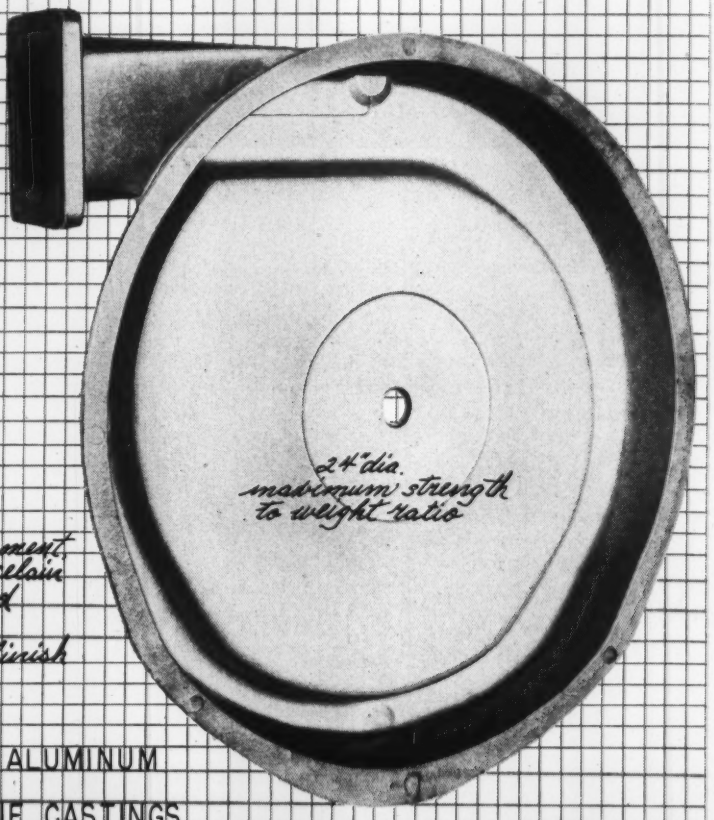

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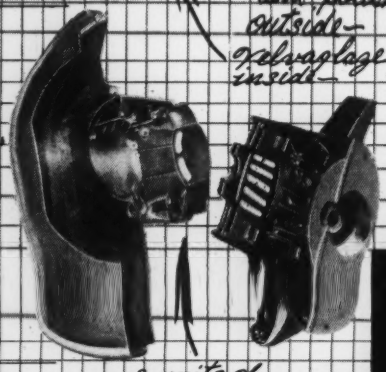

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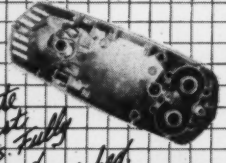

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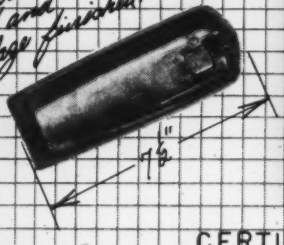

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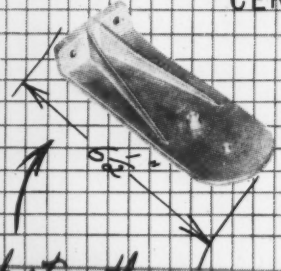

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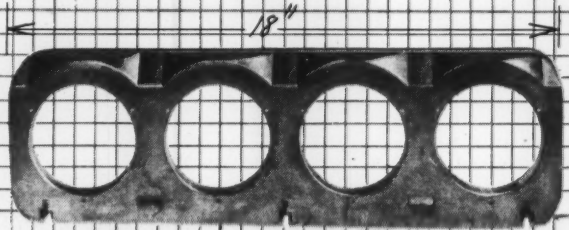

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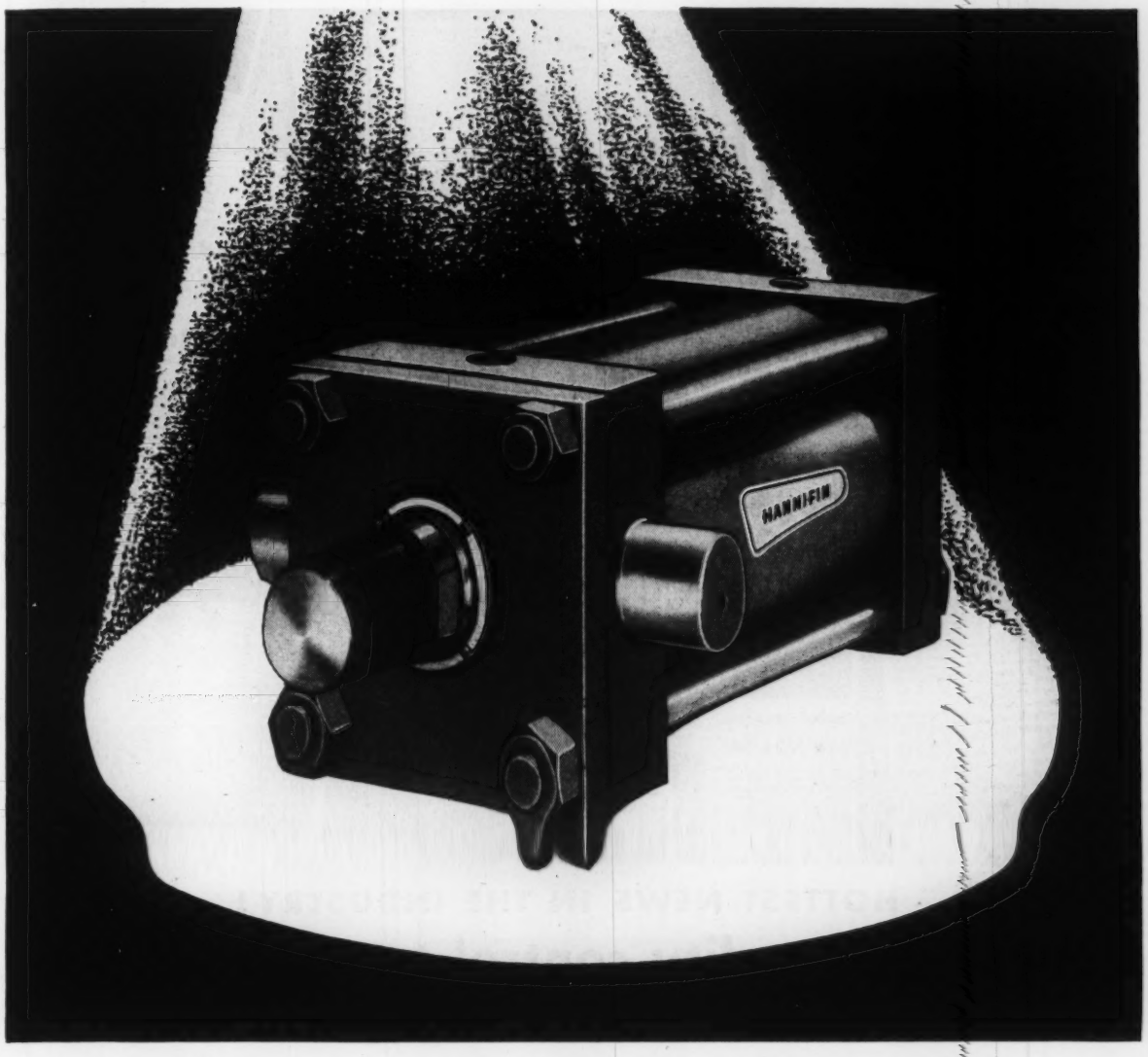


When a name is your guarantee of both quality and service

Always. When you specify Hannifin as your air and hydraulic cylinder source.

Let's talk quality. Hannifin manufactures *five* different lines of cylinders. All are made of the finest materials... to the most exacting standards for concentricity and surface finishes... and to proper tolerances for easy, accurate mounting. There are bore sizes and mounting styles to suit every requirement and types of construction to meet every preference.

What kind of service do you need? Hannifin will ship any normal quantity of standard cylinders within 48 hours—in any stroke to 60 inches! Special rod ends, special packings and certain special mountings take only a little longer.

Another service. To help you choose, there's an experienced Hannifin field engineer as near as your telephone. And, when your requirements are really urgent, you can call Hannifin Cylinder Sales at Des Plaines. Your order can be in the shop the same day.

HANNIFIN

MAIL THIS COUPON FOR PROMPT ACTION

- ☐ Have Field Engineer call at once
- ☐ Have Field Engineer stop by soon
- ☐ For the present, just send complete catalog information on Hannifin cylinders including prices

Hannifin Corporation, 515 S. Wolf Rd., Des Plaines, Ill.

Name.....*Title*.....
Company.....
Address.....
City.....*Zone*.....*State*.....

—ITEM 608—

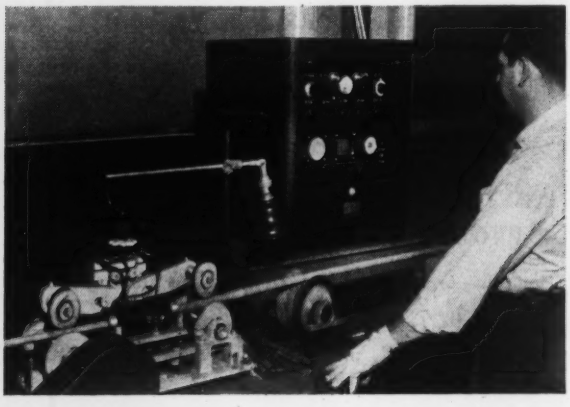
WHAT'S NEW
Detects Tiny Flaws in Tubing
A Cheaper, Better, Faster Test
For Better Quality Stainless Tubing
High-Speed Unit Performs Three-Way Inspection
Nondestructive Testing of Stainless Tubing at Production Speeds
Quality Unit Sees 100% of Tube
NEW PRODUCTS
Machine Signals Flaws in Steel With a "Beep"

HOTTEST NEWS IN THE INDUSTRY!

Latest quality control test assures better-than-ever *Carpenter* Stainless Tubing

The news is really getting around that Carpenter Stainless Tubing now undergoes the most exacting and thorough non-destructive test ever developed for quality control of austenitic types. Variations in composition, gauge, sub-surface and surface conditions are detected at production speeds. Flaws not revealed by hydrostatic tests are brought to light as this new testing device critically scans the entire I.D. and O.D. periphery of the tubing.

This notable advance in quality control means that Carpenter Stainless Tubing is now, more than ever, your best buy for life-long, trouble-free service. So, whenever you need stainless tubing for pressure or mechanical applications, give your equipment the advantage of Carpenter quality . . . more companies are. Call on your nearby Carpenter Distributor or Representative for any additional information you desire, or write to . . .



MEMBER FORGED STEEL TUBING INSTITUTE

The Carpenter Steel Company,
Alloy Tube Division, Union, N. J.

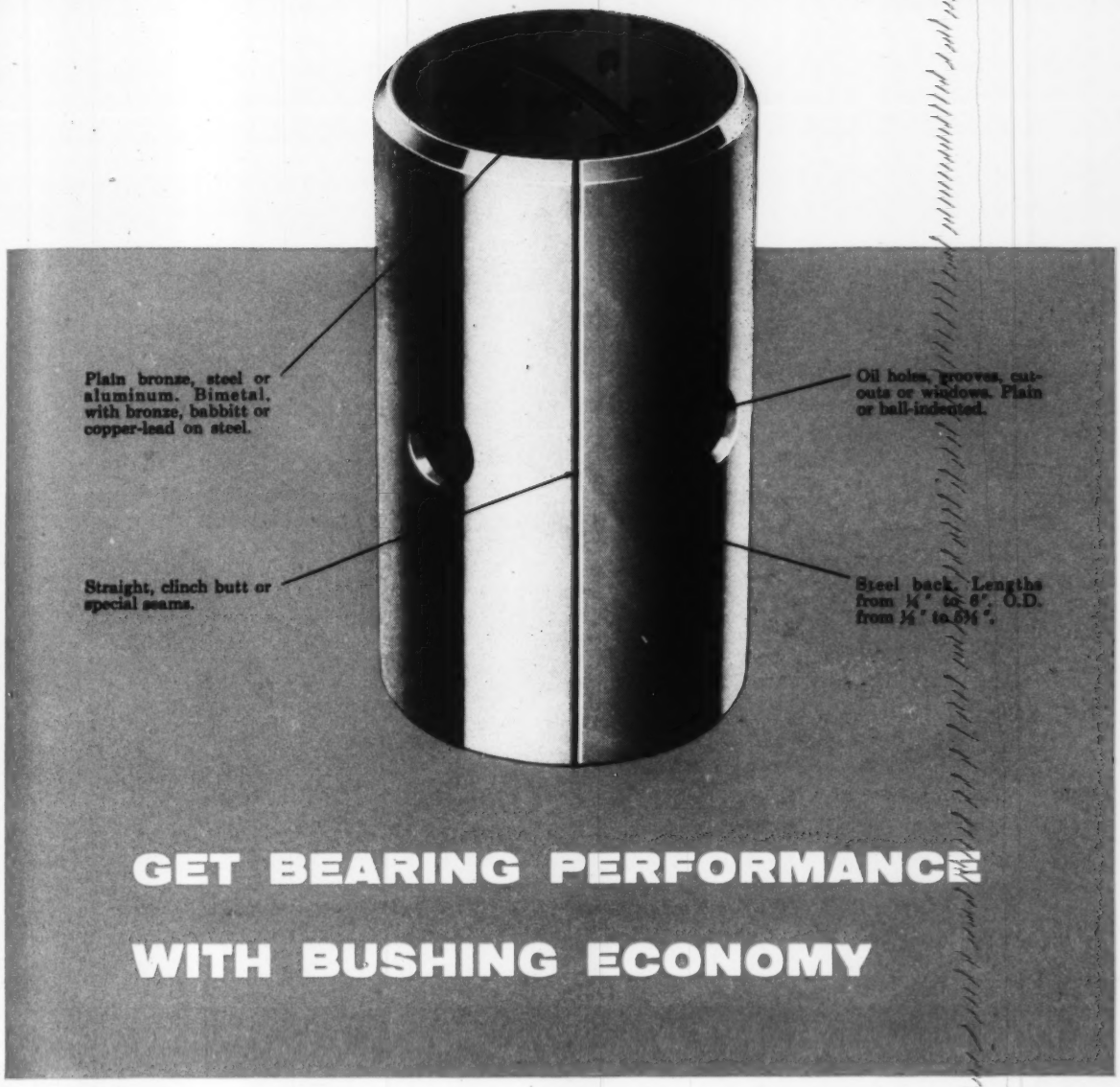
Export Dept.: The Carpenter Steel Co., Port Washington, N. Y.—"CARSTEELCO"

Carpenter

more than corrosion resistance

Stainless Tubing & Pipe

—ITEM 609—
For More Information Circle Item Number on Yellow Card—page 19


Plain bronze, steel or aluminum. Bimetal, with bronze, babbitt or copper-lead on steel.
Straight, clinch butt or special seams.
Oil holes, grooves, cut-outs or windows. Plain or ball-indented.
Steel back. Lengths from ¼" to 8". O.D. from ½" to 6¼".

GET BEARING PERFORMANCE WITH BUSHING ECONOMY

For many applications our bimetal rolled split bushings give the needed bearing performance characteristics, but at lower bushing costs. Lining alloys to meet specific requirements. Controlled hardness. Large capacity. Complete engineering service. Address:

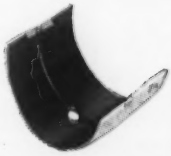
FEDERAL-MOGUL

DIVISION, Federal-Mogul-Bower Bearings, Inc.
11045 Shoemaker, Detroit 13, Michigan

BABBITT-LINED BEARINGS

BEARING-SURFACED THRUST WASHERS

SPACER TUBES


COPPER-LEAD BEARINGS

FEDERAL Mogul
SINCE 1899

RESEARCH · DESIGN · METALLURGY · PRECISION MANUFACTURING

—ITEM 610—
Next Page—ITEM 611→

GENERAL ELECTRIC
DIRECT CURRENT MOTOR
ERIE PA

rrent Motor

KINAMATIC* a new standard

in direct-current motors, gives your machines wider speed ranges, greater output

To meet modern industrial needs for faster, more automatic, more continuous production, General Electric has designed an entirely new direct-current motor—the d-c Kinamatic.

Designed for Automation—Now, a direct-current motor has been designed for the modern job it has to do—either as individual motor drive or in regulating systems. The new General Electric d-c Kinamatic motor supplies the wide speed range and versatility required for today's manufacturing methods. It is designed for the close control of machines and split-second timing of processes essential to higher output.

Accelerated Production—The new d-c Kinamatic motor will modernize your equipment, give it increased power, higher speeds, greater output capacity. With the quick-acting G-E Kinamatic motor, your machines will process a greater variety of products . . . faster . . . easier . . . and with less maintenance and spoilage.

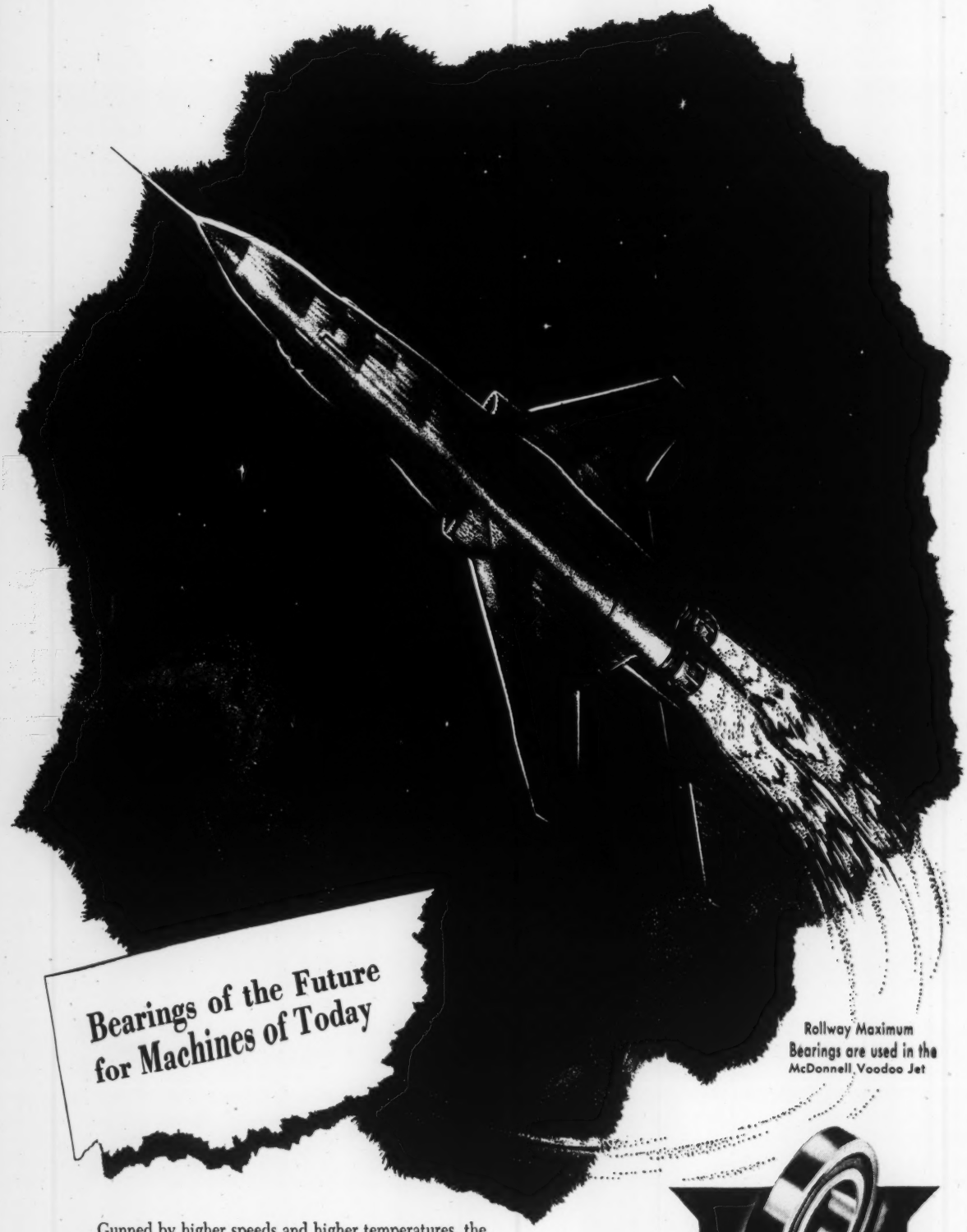
More Powerful—By combining advanced design with improved materials and manufacturing techniques, General Electric engineers have packed more power into the entire Kinamatic line. The powerful Kinamatic motor, with new stamina and durability, is ready to become one of your most effective weapons for keeping costs down, for meeting competition, for boosting productivity levels.

Engineering Help—Industrial specialists in 149 conveniently located General Electric Apparatus Sales Offices have the complete story on how the new d-c Kinamatic motors and generators can benefit your operation. For full details, contact your G-E Sales Representative, or write for Bulletin GEA-6355. *Direct Current Motor and Generator Department, General Electric Company, Erie, Pennsylvania.* 813-1

* Trade Mark of the General Electric Company

Progress Is Our Most Important Product

GENERAL ELECTRIC



Bearings of the Future for Machines of Today

Rollway Maximum Bearings are used in the McDonnell Voodoo Jet

Gunned by higher speeds and higher temperatures, the performance demand for anti-friction bearings rises sharply every year. Here at Rollway, we strive always to keep abreast of the trend, and even to anticipate it. In precision, dimensional stability and simplicity, Rollway Maximum Bearings offer performance based on advanced thinking to original equipment and replacement buyers of today.

Start now, up-grade both your production machinery and your products with Rollway *bearings of the future*. Rollway Bearing Company, Inc., Syracuse 4, N. Y. Manufacturers of a complete line of radial and thrust cylindrical roller bearings.

ROLLWAY
Maximum
ROLLER BEARINGS

ENGINEERING OFFICES: SYRACUSE • BOSTON • CHICAGO • DETROIT • TORONTO • PITTSBURGH • CLEVELAND • MILWAUKEE • SEATTLE • HOUSTON • PHILADELPHIA • LOS ANGELES • SAN FRANCISCO

—ITEM 612—

For More Information Circle Item Number on Yellow Card—page 19

(Advertisement)

Design data on adhesives

Armstrong

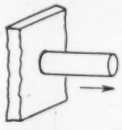
ADHESIVES • COATINGS • SEALERS

NUMBER TWO

Strengthening a common angle joint

In redesigning a common angle joint (or any other ordinary joint) to give maximum strength with adhesives, four basic rules must be kept in mind.

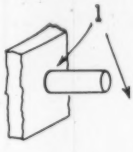
1. Make the bonded area as large as possible.
2. Make the maximum proportion of bonded area contribute to strength.
3. Stress the adhesive in the direction of its maximum strength.
4. Minimize stress in the direction in which the adhesive is weakest.



Here's how these rules can be applied:

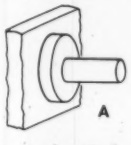
If the load is in the direction of the arrow, then stress distribution will yield high strength.

If the load is not exactly at right angles to the plane of the joint, the result will be a concentration of stress, a cleavage force (in this case at 1).



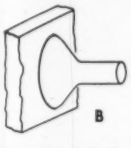
REMEDY

A. Increase area (better)



Bonded area has been made as large as possible. (Rule 1) Maximum proportion of bonded area now contributes to strength. (Rule 2)

B. Increase area and reduce stiffness at edge of joint (best)



Bonded area has been made as large as possible. (Rule 1) Maximum proportion of bonded area now contributes to strength. (Rule 2) Stress is now minimized in the direction in which the adhesive is weakest. (Rule 4)

For more information

Write for a copy of "Armstrong Adhesives, Coatings, and Sealers." Armstrong Cork Company, 8004 Dean St., Lancaster, Penna.

How to prepare surfaces for bonding

To attain optimum results with adhesives, the surfaces of the materials to be bonded must be clean. The amount of surface preparation necessary may be influenced by the type of adhesive used or the ultimate requirements of the bond.

Nonstructural adhesives, such as the pressure-sensitive or contact types, rubber cements, and asphalt adhesives, perform satisfactorily if the surface is free of dust and dirt, grease and oil, loose scale and corrosion products.

Where high-strength bonds are required, surface preparation must be more thorough. Chemical cleaning is preferred where the size of the production operation warrants installation of the proper equipment. Mechanical methods are desirable on operations where the number of assemblies to be bonded is small or where chemical cleaning would cause deterioration of part of the assembly.

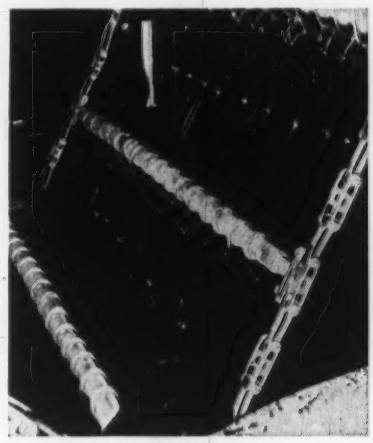


PHOTO COURTESY CHEVROLET-DETROIT GEAR AND AXLE DIV., GENERAL MOTORS CORP.

Before bonding, brake shoes are washed and pickled, then immersed in varnish dip and dried.

Listed below are typical procedures for cleaning materials frequently fastened by adhesives.

Aluminum may be cleaned with acidic or alkaline cleaners. Preferred alkaline cleaner of sodium metasilicate and a wetting agent in water at a temperature of 160° to 180° F. cleans aluminum in 4 to 5 minutes. Aluminum should be immediately rinsed with water. (A chromic acid rinse after alkaline cleaning prevents corrosion by residual alkali.)

Cleaning methods for spot welding are satisfactory for bonding. Preferable acidic cleaner consists of a solution of sulphuric acid and sodium dichromate at 140° to 160° F.

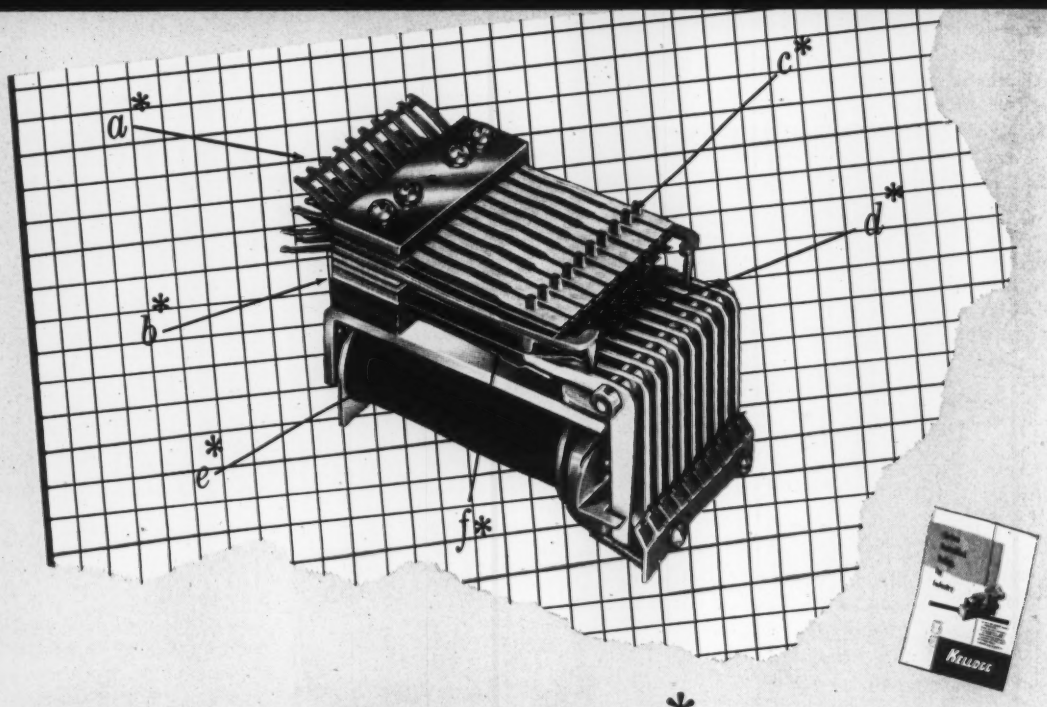
Steel should be free of rust and mill scale as well as dirt and grease. Use an alkaline cleaner to remove grease and dirt and follow with an acid pickling operataion. (Pickling of high-carbon steel and certain alloys often leaves a smut or residue which may be removed mechanically while wet or chemically with oxidizing agents.) Clean steel parts should be coated immediately to prevent rust formation.

Magnesium may be cleaned by brushing lightly with a fine wire brush followed by hot alkaline cleaner and water rinse, or by anodizing. Magnesium supplied with conventional surface treatments sometimes can be used as is, but surface contamination should be removed with solvent. Common practice in the aircraft industry, for example, is to clean the metal, apply coat of zinc-chromate primer, and bond right over it.

Plastics should be sanded prior to bonding to remove mold finish and mold release agents. Flexible vinyl plastic sheets normally require no cleaning other than surface dirt removal. Other plastics may be wiped with a solvent; however, true solvents for the plastic normally should not be used as they may cause distortion, excessive softening, crazing and cracking.

Vulcanized Rubber parts are often contaminated with mold release agents or by plasticizer or wax exudation. Silicone mold release agents prevent good bonds, as the silicone greatly impairs adhesion to the rubber. Remove talc and water-soluble mold-release agents by washing with water; plasticizer and wax, by washing with solvent. Solvent used depends on the specific rubber; toluol generally is satisfactory, but it should be used with care, since it attacks some types of rubber. Light abrasion of the rubber surface improves adhesion.

58 years of know-how gives you complete service data + designs that cut costs in production



We have been making and improving relays for more than 58 years. The use of these relays in our own equipment has helped to make Kellogg the leader in the independent telephone field.

A typical example is this sequence relay, "the Kellogg Magnetic Impulse Counter." This unique counter eliminates sliding contacts, mechanical rachets, etc. . . . the counting sequence is controlled electromagnetically, with relay-type contacts used throughout. Production advantages include: simplified circuitry, reduced size, lower cost and longer life.

You can save design time and cut production costs because our intimate experience as a relay-user, as well as relay-maker, enables us to develop relays that are rated to meet your requirements . . . build them to stand up in your equipment, for a lifetime of service.

* *For the A.B.C.'s of the Magnetic Impulse Counter and other Kellogg relays use the attached card to send for this Kellogg Relay Bulletin.*

KELLOGG
A DIVISION OF I T & T

KELLOGG
Switchboard & Supply Co.
Industrial Sales Dept.
A Division of International Telephone & Telegraph Corp.
79 W. Monroe St., Chicago 3, Ill.

☐ Please send me the booklet on Kellogg Relays

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A Division of International Telephone and Telegraph Corporation
Sales Offices: 79 W. Monroe St., Chicago 3, Ill.

QUALITY COMPONENTS FOR INDUSTRIAL CONTROL
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Los Angeles 13, Calif.
Vandyke 6759

Export Distributor:
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50 Church Street
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—ITEM 615—

For More Information Circle Item Number on Yellow Card—page 19

ANOTHER NEW HOUGHTON DEVELOPMENT IN PACKING DESIGN

HOMOGENEOUS RUBBER | FABRICATED RUBBER | LEATHER

STANDARD STACK HEIGHT

for "V" Packings

Good news for the designer! This new packing development standardizes the stack height of *all* Houghton "V" packings. Simply determine the number of packings needed in the gland (according to your pressure requirements) . . . then allow for the specified dimension in your drawing. Whether you use homogeneous rubber, fabricated rubber or leather "V's" . . . they'll fit!

You can forget "special" dimensions set up by various packing manufacturers for particular types of packings. Standardize on stack height with packings from Houghton and you'll save time and money from the drawing board on!

The leadership in hydraulic know-how is typical of Houghton, which supplies all types of hydraulic and pneumatic packings, as well as a complete line of hydraulic oils and fluids.

Standardize on Houghton. You'll get the newest first—and the best always. Call your Houghton Man and let him explain Houghton's Hydraulic Service. E. F. Houghton & Co., 303 W. Lehigh Ave., Philadelphia 33, Pa.

. . . product of

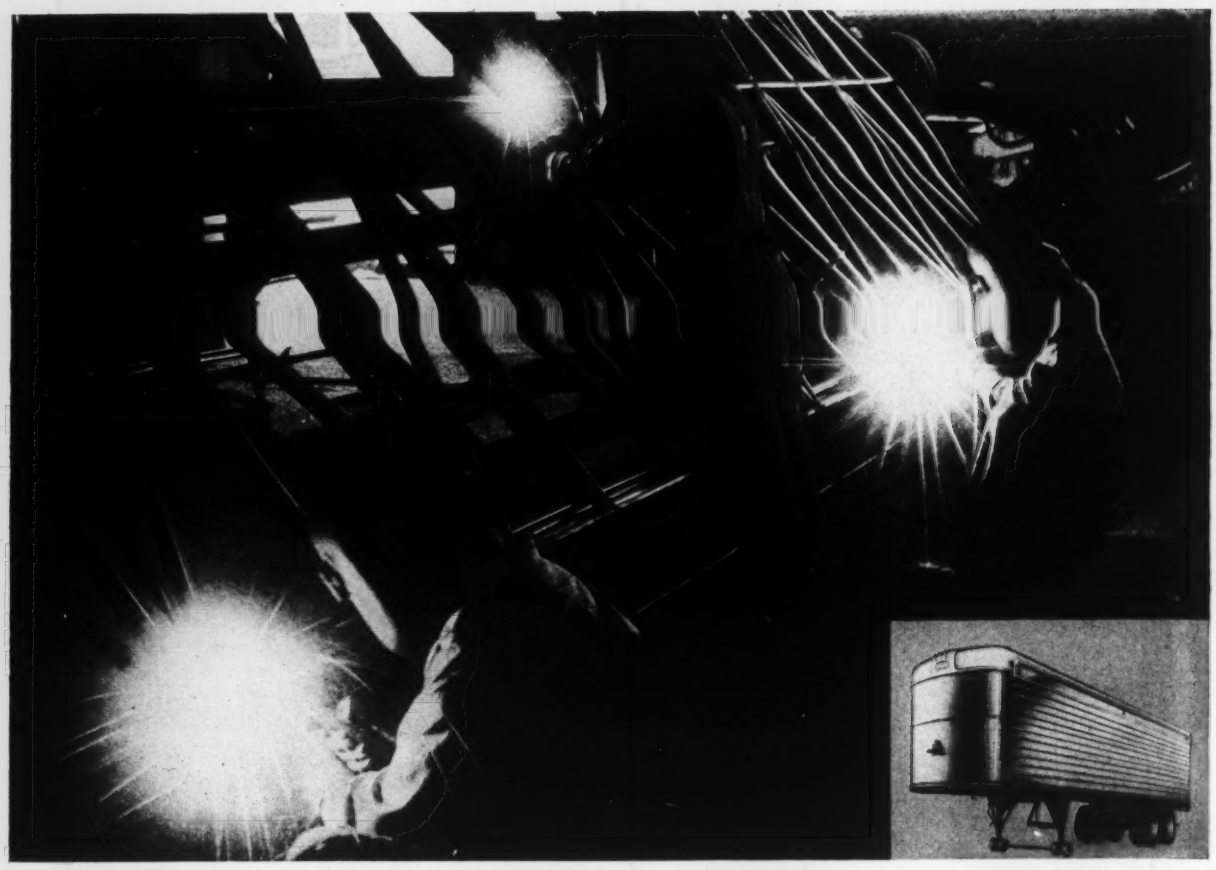
E. F. HOUGHTON & CO.

PHILADELPHIA · CHICAGO · DETROIT · SAN FRANCISCO

Ready to give you on-the-job service . . .

—ITEM 616—

For More Information Circle Item Number on Yellow Card—page 19



The Champion is a feather-weight van built for heavy-duty service. For extra strength Airco welding rods, Easyarc 12 and Airco 387 electrodes are used *exclusively* to join the tough-but-light tubular steel frame. Faster, more economical production was also achieved through the use of Airco Heliwelding equipment, cutting torches and accessories.

4 Airco products help put new champion on the road —lighter by one thousand pounds!

The Dorsey Trailer Company, Elba, Alabama, wanted to cut the weight of its vans by a thousand pounds – without cutting durability or strength. An aluminum and tubular steel design solved the first part of the problem. The selection of Airco products for the all-important welding job neatly took care of the rest.

From planning to production you can rely on assistance – and completely unbiased recommendations – from Airco Technical men. For Airco is the leading supplier-manufacturer of all kinds and every type of welding and flame cutting processes, their controls, supplies and accessories. Write to Airco for free literature describing Heliwelding equipment and Airco electrodes.

WELDING SHOW

VISIT OUR BOOTH

AT THE FRONTIERS OF welding PROGRESS YOU'LL FIND . . .

AIRCO®

Offices and dealers in most principal cities

AIR REDUCTION SALES COMPANY

A division of Air Reduction Company, Incorporated, New York 17, N. Y.

On the west coast — Air Reduction Pacific Company

Internationally — Airco Company International

In Cuba — Cuban Air Products Corporation

In Canada — Air Reduction Canada Limited

Products of the divisions of Air Reduction Company, Incorporated, include: **AIRCO** – industrial gases, welding and cutting equipment, and acetylenic chemicals • **PURECO** – carbon dioxide, liquid-solid ("DRY-ICE") • **OHIO** – medical gases and hospital equipment • **NATIONAL CARBIDE** – pipeline acetylene and calcium carbide • **COLTON** – polyvinyl acetates, alcohols, and other synthetic resins.

—ITEM 617—

Phenolic molded device makes flashlight

Safe in explosive atmospheres

Safety is achieved by use of a spring-loaded contact within the reflector assembly so designed that if the bulb of the lamp is broken, the electrical circuit will be instantly opened before the filament can ignite inflammable or explosive mixture of gas in the surrounding atmosphere.

The intricate working parts of the reflector assembly are molded of BAKELITE Brand Phenolic Plastic BMG 5000 Black. Their positive, unhampered action demonstrates the dimensional stability and strength of this material. In production, the reflector unit with its mounts and guides, exterior threads, and slots for the wire guard are formed in one operation with a 9-cavity compression mold. The retainer ring that holds the wire guard is produced in a 12-cavity high-speed plunger mold.

For further information on a wide range of phenolic plastics, write Dept. OP-103.

Reflector assembly parts made of BAKELITE Phenolic Plastic by **Auburn Button Works, Inc.**, Auburn, N. Y., for "Eveready" Safety Type Flashlight, produced by National Carbon Co., A Division of Union Carbide and Carbon Corporation, N. Y. 17, N. Y.

BAKELITE
BRAND
PHENOLIC PLASTICS

BAKELITE COMPANY

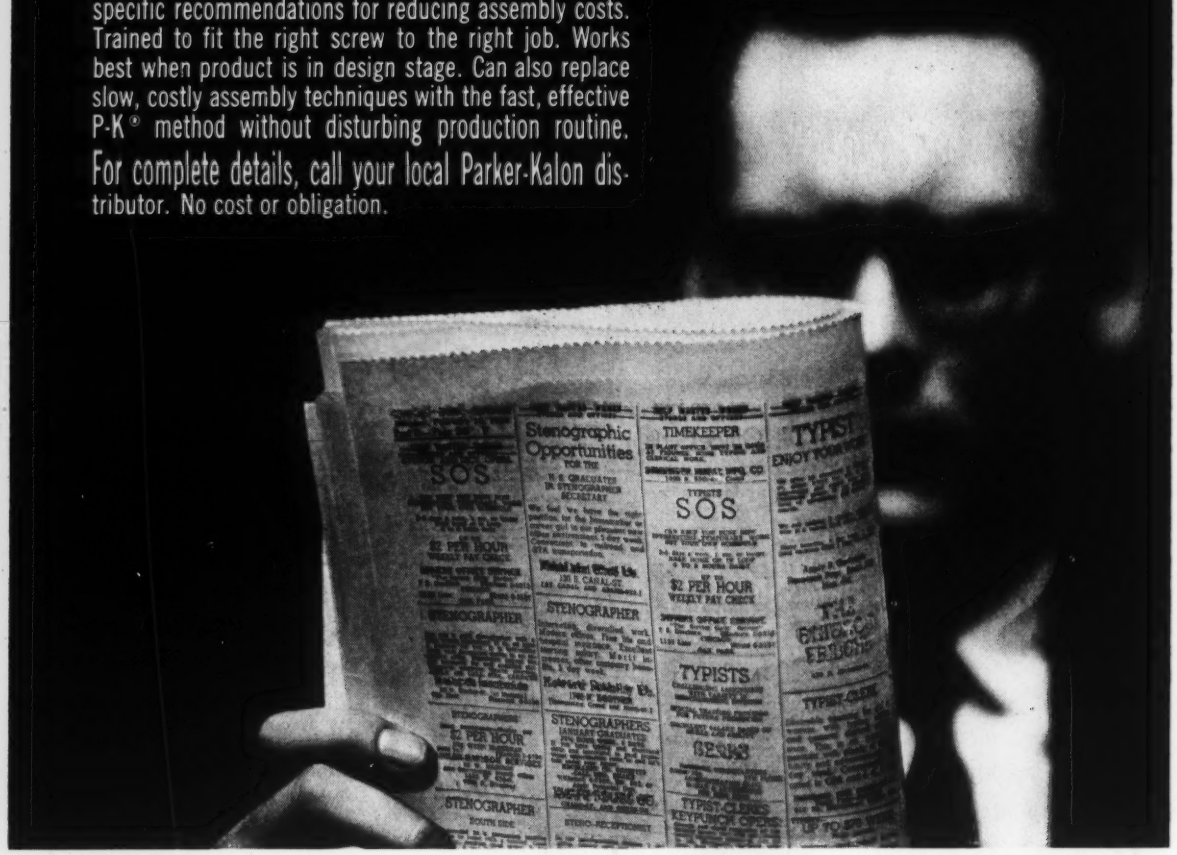
A Division of Union Carbide and Carbon Corporation UCC 30 E. 42nd St., N.Y. 17, N.Y.

In Canada: Bakelite Company, Division of Union Carbide Canada, Limited, Belleville, Ontario

The terms BAKELITE, EVEREADY and the Trefoil Symbol are registered trade-marks of UCC

JOB WANTED

Experienced Assembly Engineer. Successful record of effecting substantial assembly savings in 7 out of 10 cases. Will check your fastening problems and make specific recommendations for reducing assembly costs. Trained to fit the right screw to the right job. Works best when product is in design stage. Can also replace slow, costly assembly techniques with the fast, effective P-K® method without disturbing production routine. For complete details, call your local Parker-Kalon distributor. No cost or obligation.



this specialist wants to work for you!

Call in a P-K Assembly Engineer and find out how you can profit through reduced assembly costs the P-K way. Take advantage of this unique Parker-Kalon service—another of the many reasons why users say—"if it's P-K . . . it's O. K."

PARKER-KALON DIVISION, GENERAL AMERICAN TRANSPORTATION CORPORATION—CLIFTON, NEW JERSEY

PARKER-KALON® *fasteners*

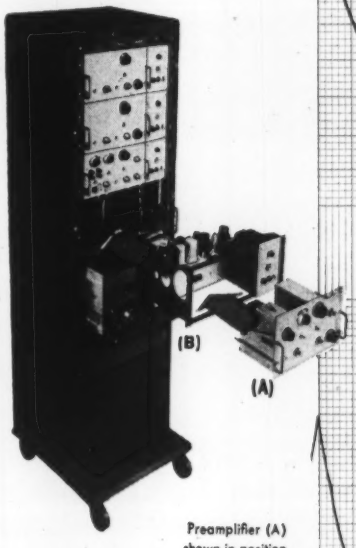
Sold Everywhere Through Leading Industrial Distributors. Warehouse in Chicago, Illinois

—ITEM 619—

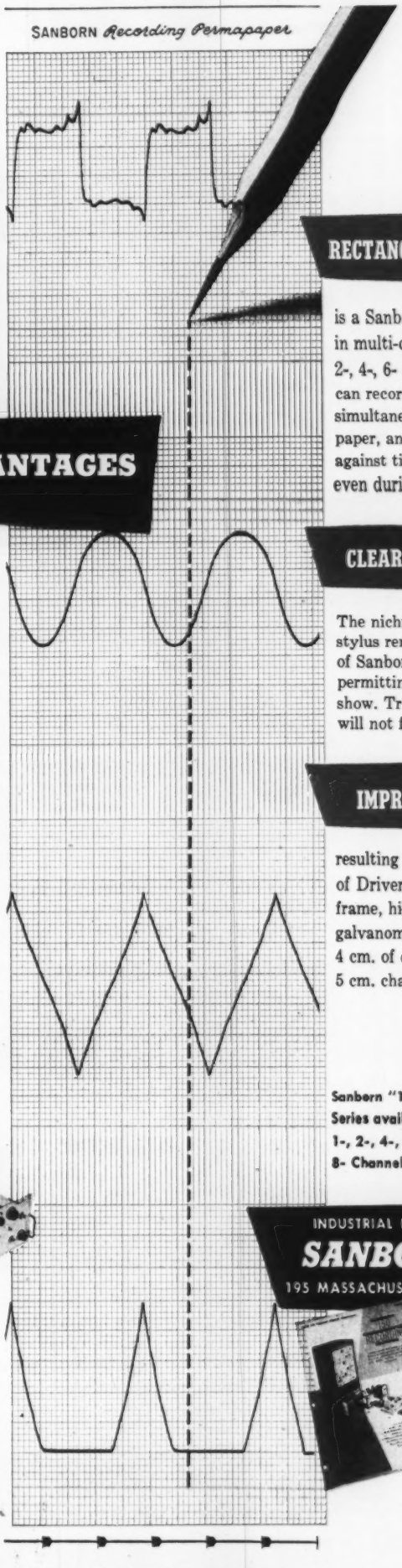
For More Information Circle Item Number on Yellow Card—page 19

ALL SANBORN 150 SERIES OSCILLOGRAPHIC RECORDERS PROVIDE THESE SPECIFIC ADVANTAGES

THE three foremost operating advantages of a Sanborn "150" are evident in the record, and are given at the right. Equally popular with industrial users is the *wide versatility* of these systems. Each one comprises a basic assembly to which the user adds his choice of an interchangeable, plug-in type preamplifier for each channel. Presently available different preamplifiers now number *eleven*.



Preamplifier (A) shown in position to plug into a Driver Amplifier with Power Supply (B) which are normally already in place in the Basic Cabinet Assembly



RECTANGULAR COORDINATE RECORDING

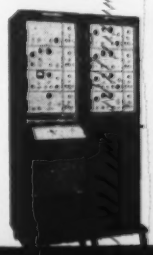
is a Sanborn feature that is especially valuable in multi-channel recording. The user of a 2-, 4-, 6- or 8-channel "150" system can record interrelated events simultaneously on one strip of record paper, and then correlate them against time quickly and accurately, even during the recording.

CLEAR, SHARP, INKLESS TRACINGS

The nichrome ribbon tip "150" heated stylus removes the white opaque surface of Sanborn recording paper (Permapaper) permitting the black undercoating to show. Tracings are permanent, will not fade or smudge.

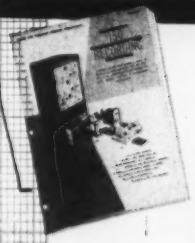
IMPROVED OVER-ALL LINEARITY

resulting from current feedback design of Driver Amplifiers and new shorted coil frame, high torque (200,000 dyne cm.) galvanometers. Maximum error over middle 4 cm. of chart: 0.25 mm . . . over entire 5 cm. chart width: 0.5 mm.



Sanborn "150" Series available in 1-, 2-, 4-, 6- and 8- Channel Systems.

INDUSTRIAL DIVISION
SANBORN COMPANY
195 MASSACHUSETTS AVENUE, CAMBRIDGE 39, MASS.

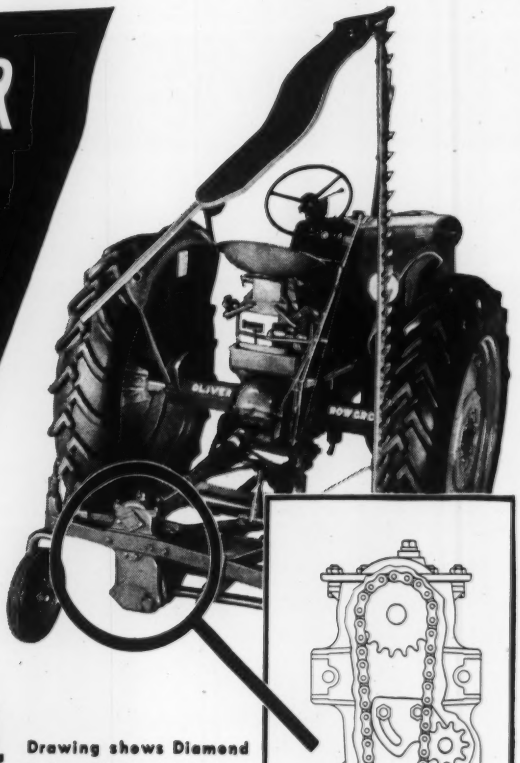


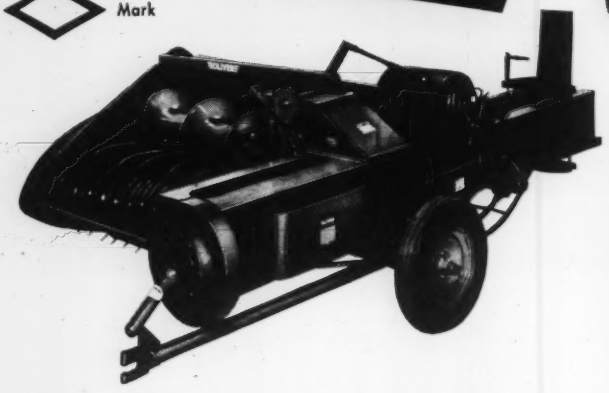
A new "150" Catalog provides complete descriptive data, specifications and prices on all 150 Systems, Accessories and Cabinets. A copy will be sent on request.

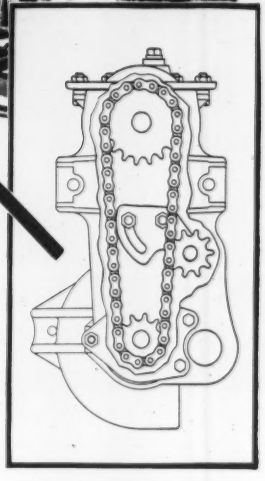
—ITEM 620—

NEW OLIVER MOWER AND TWINE-TIE BALER USE DIAMOND ROLLER CHAINS FOR EFFICIENCY, LONG LIFE!

Trade ® Mark







Drawing shows Diamond Roller Chain drive from power take-off shaft to cutter bar of Oliver Mower.

On the Oliver Baler, Diamond Roller Chain supplies power from the main transmission for many of the machine's operations.

◆ Where positive long-life drives are required for power transmission or the coordination of machinery functions, specify Diamond Roller Chains. Their ready adaptability, superior uniform quality and nearly 100% efficiency on long or short center drives improve machinery performance and output.

Always Preloaded. For many, many years, Diamond Chain has been preloaded after assembly for the purpose of bringing pin-bushing seating into stabilized relationship prior to field installation.

Diamond Engineers are ready to give you assistance backed by 65 years of experience.

DIAMOND ROLLER CHAINS

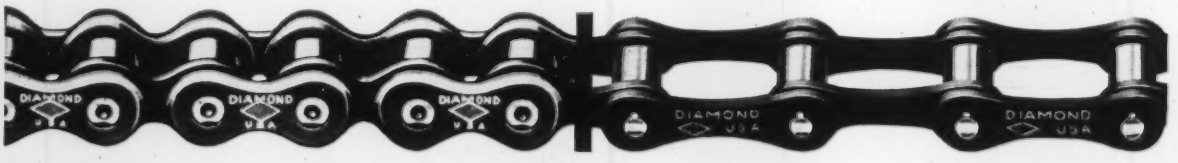
DIAMOND CHAIN COMPANY, Inc.

Where High Quality is Traditional

Dept. 435, 402 Kentucky Avenue, Indianapolis 7, Indiana

Offices and Distributors in All Principal Cities

New Catalog 734 contains complete engineering data on Stock Roller Chains and Sprockets. Copy on request.



—ITEM 621—

For More Information Circle Item Number on Yellow Card—page 19

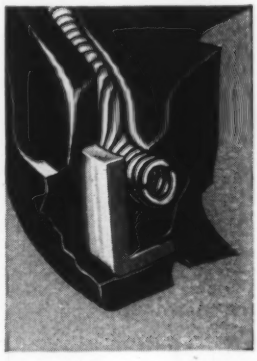
VICTOR

VICTOPRENE

K-6

OIL SEALS

Heavy-duty dual sealing at single seal cost



Type K4 with Victoprene on O.D.

For installations requiring sealing element on outer periphery and outside face, K4 seals are so designed. Otherwise, construction is identical with K6 seal as above.

The K6 offers you highly developed double lip design with integral metal O.D. case and supplementary edge sealing. Thoroughly proven on heavy-duty applications, this construction is the modern replacement for costlier compound element seals and multiple seal installations.

The K6's efficient dual function of sealing in lubricant and sealing out foreign matter permits maximum compactness in seal housing.

The sealing element is oil-, age- and heat-resisting Victoprene synthetic rubber. Exclusive Victor process of mechanical and chemical bonding combines the element and metal case into a permanent single-unit structure.

Other K6 Features

The supplementary Victoprene edge compresses against shoulder on base to assure positive O.D. seal with metal to metal O.D. press fit.

Valley between sealing lips retains initial lubricant for minimum friction and longer sealing life.

Unitary construction for minimum width requirements. Available in minimum width of ¼ inch, and for shaft diameters up to 7 inches.

Available with or without garter spring on primary sealing lip.

External or secondary sealing lip, molded with initial light interference, permits satisfactory installation. Upon installation, the primary sealing lip displaces to increase sealing efficiency of secondary member through flex action.

You Can Save with This Seal

The K6 assures finest dual sealing with single seal economy. Get complete specifications and recommendations through your Victor Field Engineer, or by writing: Victor Mfg. & Gasket Co., P.O. Box 1333, Chicago 90, Ill. *In Canada:* Victor Mfg. & Gasket Co. of Canada Ltd., St. Thomas, Ont.

VICTOR

Sealing Products Exclusively

OIL SEALS • GASKETS • PACKINGS

—ITEM 622—

For More Information Circle Item Number on Yellow Card—page 19

maximum process utilization

with MADISON-KIPP zinc and aluminum die castings

Die casting as a process has marked advantages in providing lightness, strength and stability in parts that can be cast to dimensions requiring a minimum of machining.

Seasoned skill, however, is involved in getting maximum process utilization as in the Madison-Kipp casting here illustrated, developed with the close cooperation of the user and the die designer.

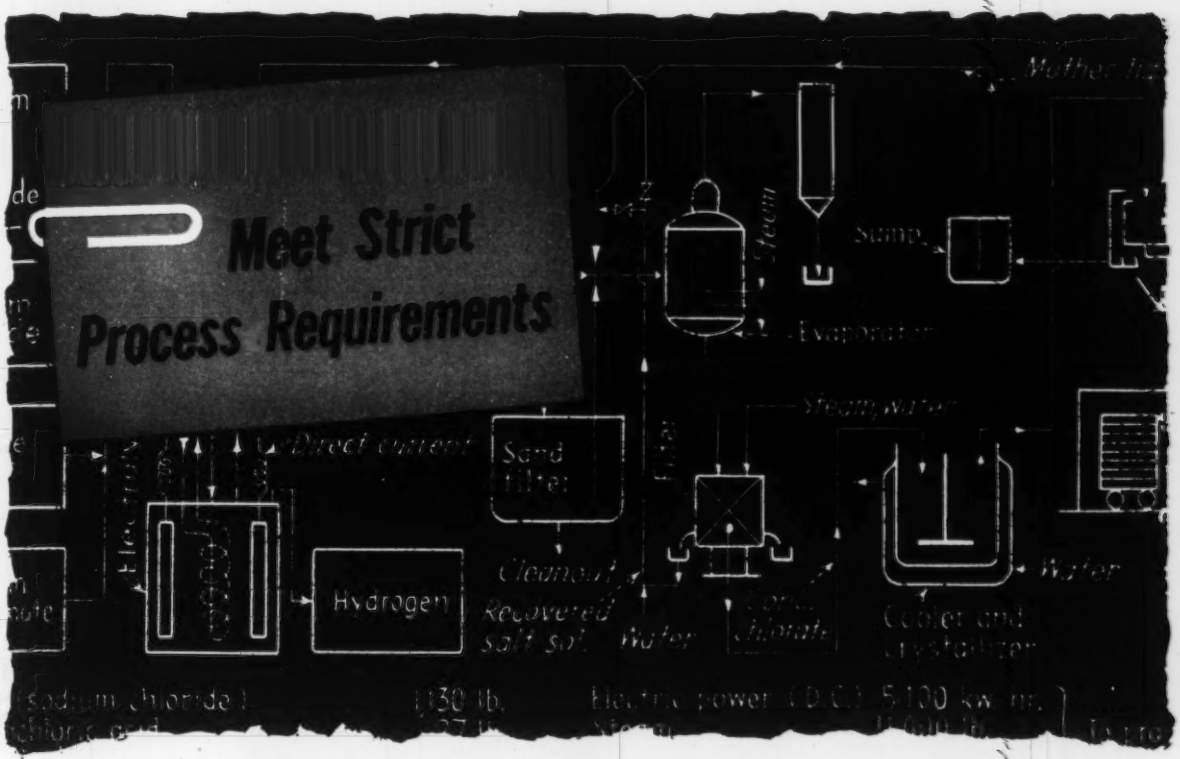
Please clip this ad as a reminder to contact us when you have die casting requirements.

kipp

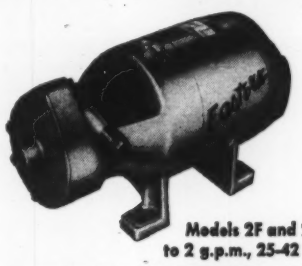
MADISON-KIPP CORPORATION
210 WAUBESA STREET • MADISON 10, WIS., U. S. A.

• Skilled in Die Casting Mechanics • Experienced in Lubrication Engineering • Originators of Really High Speed Air Tools

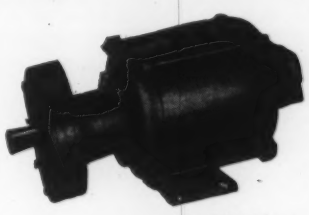
—ITEM 623—
For More Information Circle Item Number on Yellow Card—page 19



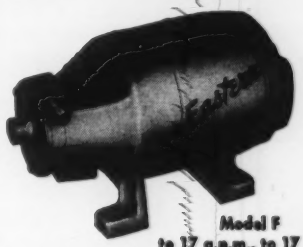
. . . with Eastern Centrifugal Pumps



Models 2F and 2J
to 2 g.p.m., 25-42 p.s.i.

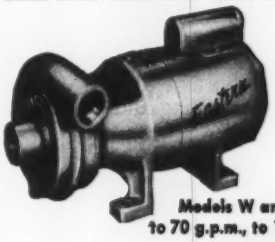


Model D-11
to 7.5 g.p.m., to 18 p.s.i.

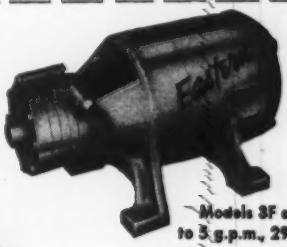


Model F
to 17 g.p.m., to 17 p.s.i.

Models U-17 and U-34
to 38 g.p.m., to 21 p.s.i.



Models W and Z
to 70 g.p.m., to 11 p.s.i.



Models 3F and 3J
to 3 g.p.m., 29-65 p.s.i.

Recent redesign of these close-coupled Centrifugal Pumps has gained tremendous ruggedness and allowed for a wide selection of power requirements. In every detail of size, weight, space requirements, power, and costs, Eastern pumps fill the bill for strict process standards.

Six standard models range from 1/8th to 3/4 H.P., with capacities up to 70 G.P.M., pressures to 65 P.S.I. Eastern Centrifugal Pumps are available in Cast Iron, Bronze, Stainless Steel, Monel, and Hastelloy "C".

Eastern's engineering service offers many special models to meet your specific needs as to capacity and construction. Recommendations entail no obligation, and your inquiries are invited.

NEW EASTERN CATALOG

Eastern Centrifugal Pump

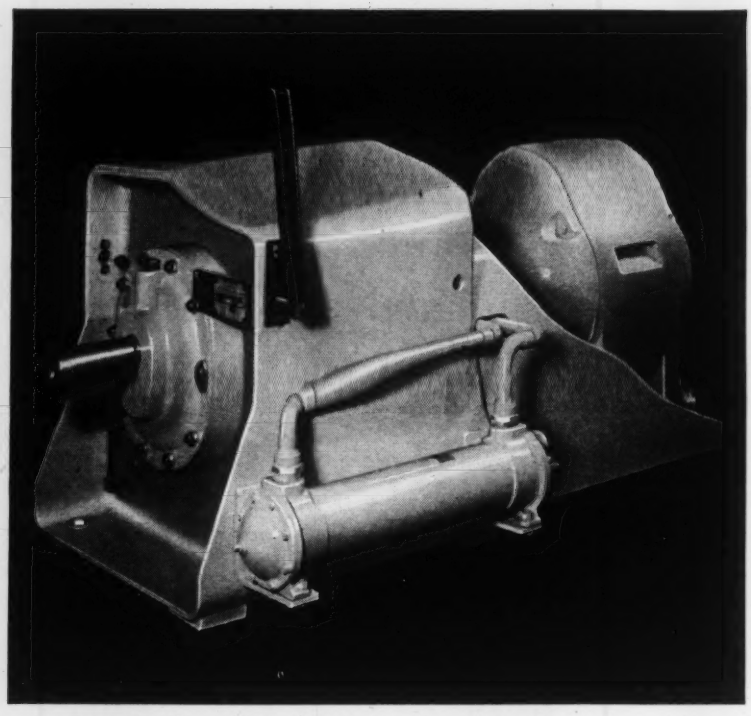
Catalog contains engineering data, performance charts, diagrams and helpful general information. Request Bulletin 1101.

Eastern

INDUSTRIES, INC.
100 SKIFF ST.
HAMDEN 14, CONN.

—ITEM 624—

Gýrol Fluid Drives limit torque to give you a built-in safety factor!



Type VS, Class 2 Gýrol Fluid Drive is available in ten sizes, 1 hp to 800 hp, speeds to 3600 rpm.

The American Blower Type VS, Class 2 Gýrol Fluid Drive not only offers adjustable, stepless speed control, but its inherent shock-absorption ability protects machinery.

For, a Gýrol Fluid Drive will limit the amount of torque which can be transmitted under overload conditions. This torque-limiting capacity can be adjusted by merely positioning the speed-control lever.

What's more, Fluid Drive permits the motor to come up to speed under almost no-load conditions—allowing simplification of motors and starting equipment for heavy starting loads.

You'll discover many more important benefits for a wide variety of industrial applications by calling our nearest branch.

FEATURES

- Can be reversed while in motion by reversing motor
- Across-the-line starting on many applications
- Motor can reach full speed before engaging load
- A compact, self-contained unit
- Trigger-action response — adjustable speed
- Speed may be controlled manually or automatically

Speed control for the paper and textile industries

Papermaking and processing machinery needs smooth starting to prevent tearing; adjustable speed to adjust machinery to humidity, paper thickness; no-load starting to keep power requirements down. Fluid Drive is the practical answer. It meets these problems easily — and without excessive maintenance. In the same manner, textile machinery needs accurate speed control to give maximum production rates within safe limits for the yarn. Again the answer is Gýrol Fluid Drive. Consult our nearest branch office or write us for information.

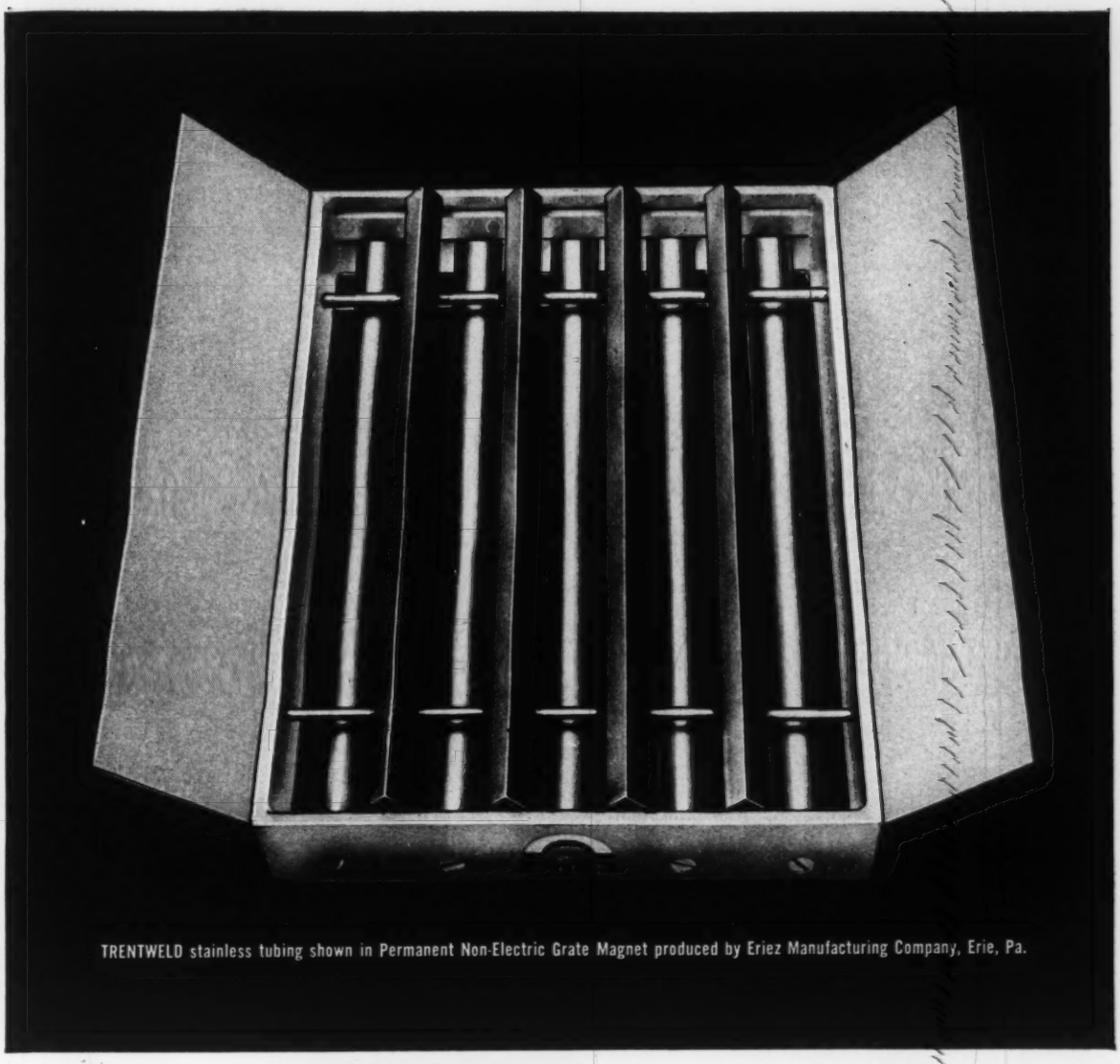
American Blower products serve industry

- AIR CONDITIONING, HEATING, VENTILATING EQUIPMENT
- MECHANICAL DRAFT EQUIPMENT
- INDUSTRIAL FANS AND BLOWERS
- CENTRIFUGAL COMPRESSORS
- GÝROL FLUID DRIVES
- DUST COLLECTORS
- REFRIGERATING MACHINES

AMERICAN BLOWER CORPORATION, DETROIT 32, MICHIGAN
CANADIAN SIROCCO COMPANY, LTD., WINDSOR, ONTARIO
Division of American-Standard

AMERICAN 75th ANNIVERSARY YEAR **BLOWER**

—ITEM 625—
For More Information Circle Item Number on Yellow Card—page 19



TRENTWELD stainless tubing shown in Permanent Non-Electric Grate Magnet produced by Eriez Manufacturing Company, Erie, Pa.

how TRENTWELD stainless tubing traps "tramp iron" in product flow...

As free-flowing products such as chemicals, grains, sugar or spices flow through this separator unit, large and small iron contamination is seized by powerful magnets and held firmly to the five stainless steel tubes.

This is a unit that's normally given long, hard use. That's why TRENTWELD stainless steel tubing is chosen to house the Alnico V magnetic elements. For stainless resists abrasion and corrosion . . . its smooth surface offers a minimum of resistance to product flow . . . and stainless is strong—lasts indefinitely. What's more, stainless is the easiest of metals to keep clean and sanitary.

And equally important to you is the fact that TRENTWELD is made by *tube mill specialists* —by the new, patented *Contour-Weld** Process. That means stainless pipe or tubing with a smoother I.D., free from any weld bead or undercut.

So when you need stainless or high-alloy pipe or tubing, make sure it's TRENTWELD. You can't buy better!

*Contour-Weld is the trade mark of the Trent Tube Company for its processes of welding pipe and tubing which is protected under U. S. Patent 2,716,692.

TRENTWELD

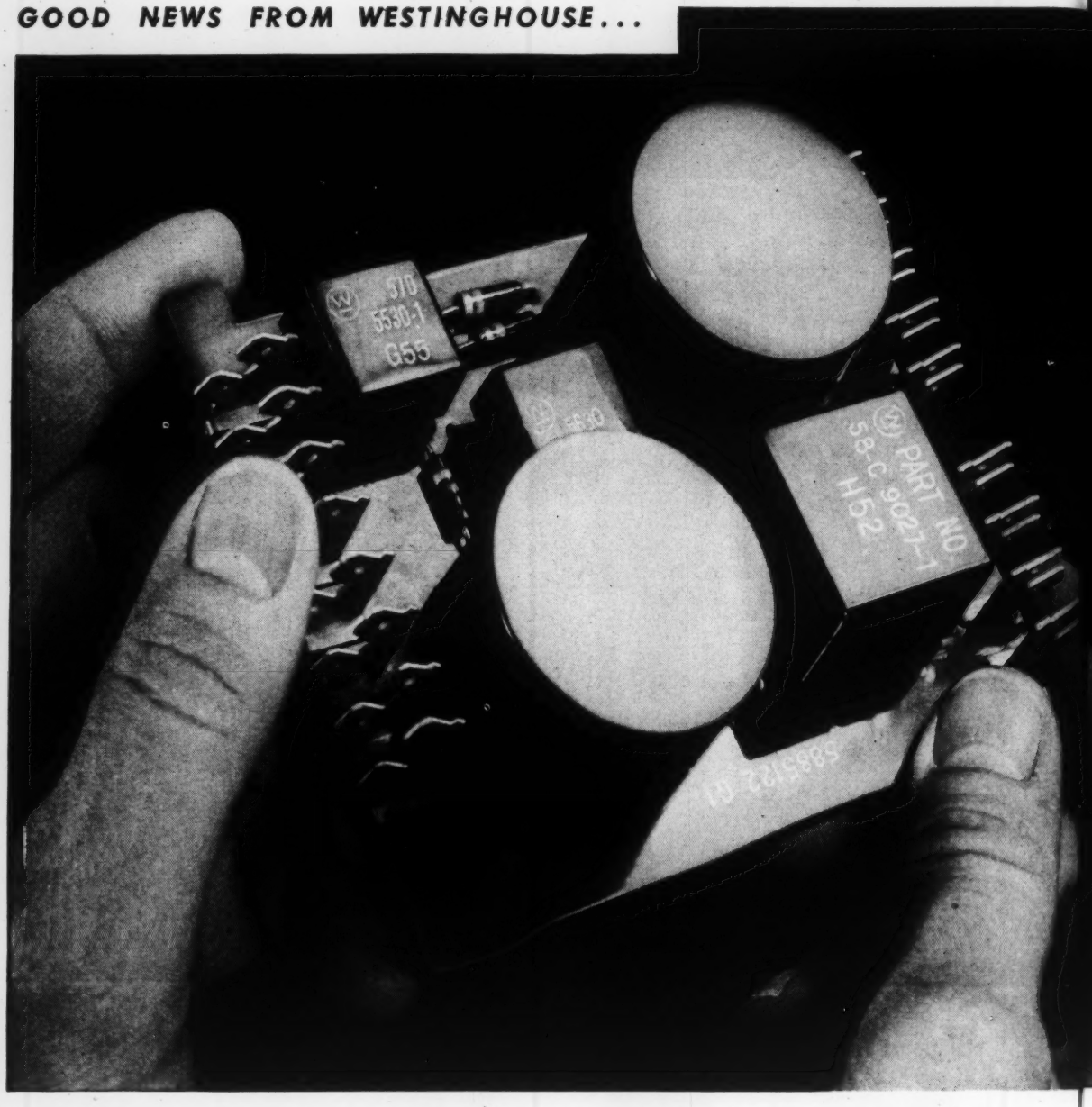
STAINLESS STEEL TUBING

TRENT TUBE COMPANY, GENERAL SALES OFFICES, EAST TROY, WISCONSIN (Subsidiary of CRUCIBLE STEEL COMPANY OF AMERICA)

—ITEM 626—

For More Information Circle Item Number on Yellow Card—page 19

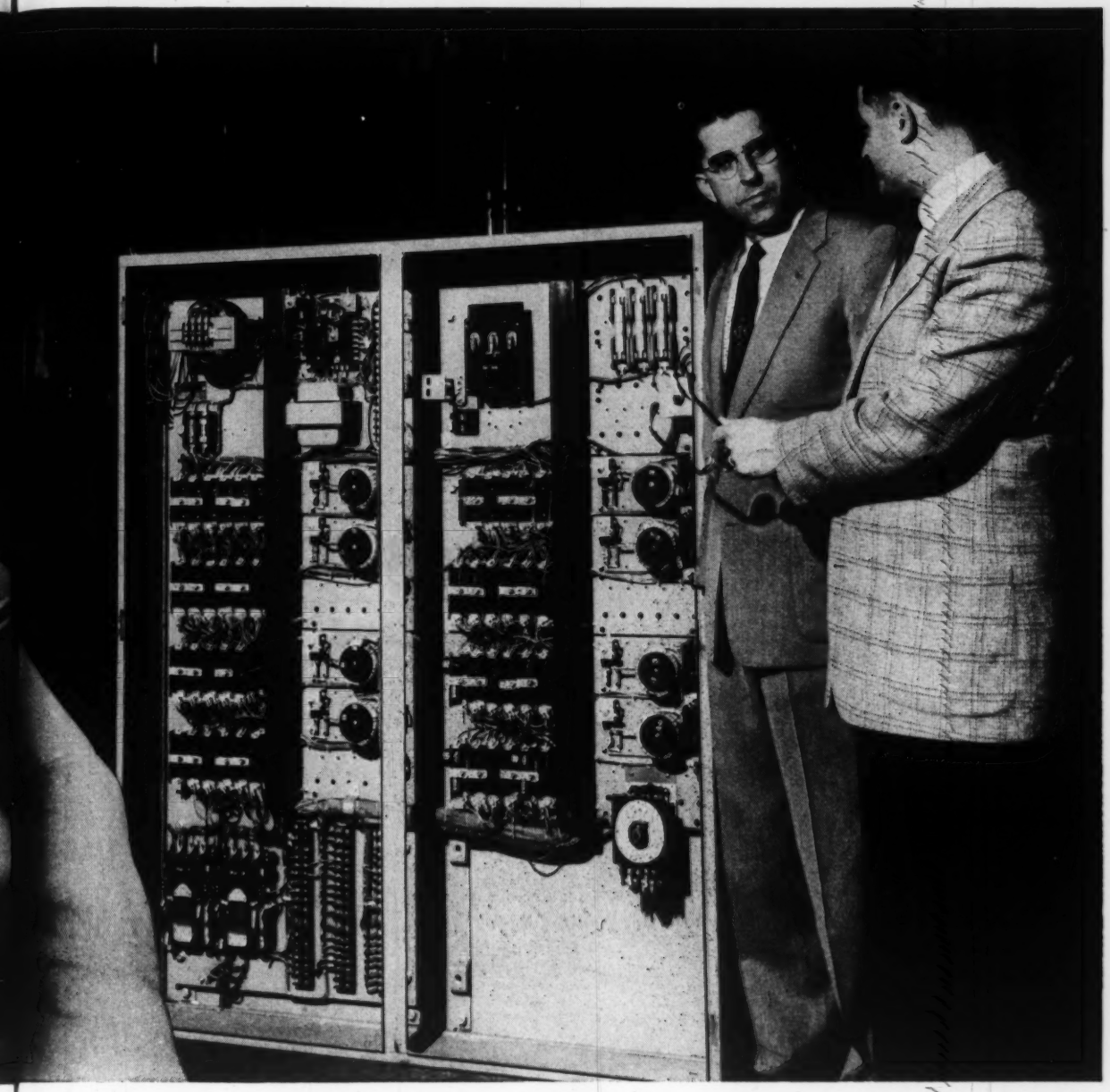
GOOD NEWS FROM WESTINGHOUSE...



THIS IS

CYPAK*

the most revolutionary industrial control advance in 25 years



Just two years ago, production and control engineers alike dreamed of the possibilities of a relay with no moving parts. A reality today, Westinghouse CYPAK introduces static control from units that fit the palm of your hand. CYPAK control has no moving parts to wear, corrode, jam or otherwise cause failure. In addition, CYPAK refines the relay art through making use of basic logic functions.

The result—static control with life at least 15 times that of conventional relays. While twenty million open-close cycles is usually the maximum life of a mechanical relay, CYPAK systems can handle that many cycles in days without a trace of fatigue.

Besides eliminating maintenance and down time, CYPAK opens new opportunities for broader, more complex control. Look into these advantages of CYPAK by calling your Westinghouse sales engineer. J-01002

* Trade-Mark

Write today for your free copy of *The Whys and Wherefores of* CYPAK, Booklet B-6584. Westinghouse Electric Corporation, 3 Gateway Center, P. O. Box 868, Pittsburgh 30, Pa.

YOU CAN BE SURE...IF IT'S Westinghouse

—ITEM 627—

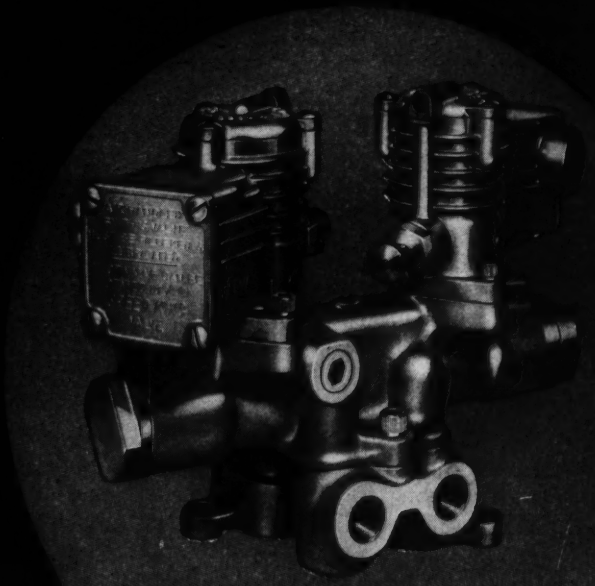
SPEED KING

the only valve guaranteed against coil burnout for life

Now—for the first time—you can eliminate coil burnout, the major source of valve trouble. That's because Speed King valves are *guaranteed against coil burnout for the life of the valve.* Unique design of Speed King valves minimizes inrush and holding current in solenoid coils. Furthermore, coils are encased in molded epoxy resin . . . proof against moisture, oil, dust and vibration.

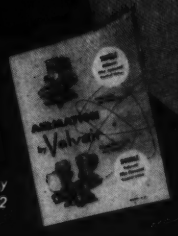
And the Speed King gives you many other "plus" advantages, too. Users report Speed Kings regularly operate over 20 million cycles. In addition to being guaranteed dependable, Speed King valves are built to JIC standards . . . are compact . . . easily adapt to any requirements for air, hydraulic or vacuum applications . . . have full line of optional attachments . . . *and are available for immediate delivery from stock.*

Check your valve requirements critically. Check performance, features, materials, guarantee, delivery. Compare—and you'll specify Speed Kings. Valvair Corporation, 154 Morgan Avenue, Akron 11, Ohio.



Double solenoid 4-way Speed King shown. Single and double solenoid types in ¼, ⅜, ½, ¾ and 1" pipe sizes for fast, reliable and controlled operation. All air-valves feature molded coil epoxy resin.

Valvair



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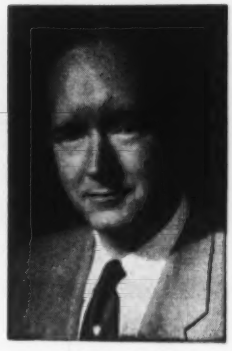
AA-9018

—ITEM 628—

For More Information Circle Item Number on Yellow Card—page 19

MACHINE DESIGN
APRIL 19, 1956



Rallying Point for Mechanisms

CONTROLLED MOTION is the common denominator underlying all machine designs. Machines for the home, for industry, for transportation, for communication — all are designed around some basic idea for using moving parts to transmit or modify force and motion for a useful task.

Much information is available on specific drive and control elements— mechanical, electrical and electronic, hydraulic and pneumatic. Certain areas such as fluid power and electronics are also well covered in periodic conferences sponsored by interested groups. But mechanisms — the devices such as linkages and cams that produce unique motions mechanically — have not received equal attention. This is despite the fact that they are generally essential links in systems that also include electrical and fluid power devices.

Sensing the evident need, Purdue University and MACHINE DESIGN jointly sponsored two conferences on mechanisms in 1953 and 1954. Interest and enthusiasm displayed at these affairs, with several hundred engineers attending each time, encouraged the sponsors to continue the program.

The third conference, originally scheduled for last Fall but postponed because of conflicts with other events, will be held on the Purdue campus on May 24 and 25 this year. A full and diversified program has been planned, including paper presentations, group discussions and workshop sessions on key subjects such as mechanism synthesis, cam design, dimension problems, and intermittent mechanisms. The social side is not being neglected. And engineers attending will find the congenial environment of a great university highly conducive to the establishment of personal friendships with fellow engineers having like interests and problems.

Located not far from the center of population of the U.S., and possessing an engineering staff that includes several members nationally known for their contributions to the literature on mechanisms, Purdue is ideally situated to become a sort of informal mechanisms headquarters. The regular conferences provide an annual meeting place both for specialists with advanced problems to discuss and for general practitioners seeking information and help.

We know of no more rewarding way to spend two days than at Purdue on May 24 and 25.

Colin Carmichael

EDITOR

A Survey of Pros and Cons on
Simplified Drafting

FEW RECENT movements in engineering have received the intense interest exercised in simplified drafting. Little wonder—it promises much by way of reduction in engineering time and cost.

For some companies, simplified drafting has passed from exploration into actual practice, and the enthusiasm of its sponsoring advocates continues strong. On the other hand, many men, while not critically skeptical, continue to examine the possibilities of simplified drafting, waiting for proof. And, at the far end of the scale, are those who reject—or denounce—the method for various reasons.

MACHINE DESIGN has sifted and sorted opinions and ideas of different companies on this subject. In this article the current attitudes—the pros and cons—are presented as quotations from some of the letters of men who have commented on this subject. Almost all sentiments expressed in these few quotations are echoed by others.

What is simplified drafting? Is it a new idea?

In a broad sense, any drawing practice that short-cuts conventional "text-book" techniques might be considered simplified drafting. Taking short cuts on drawings is no modern innovation. For example,

. . . 1917 . . . first drafting job. It was soon evident that well-made free-hand sketches were as good for a model as instrument-delineated drawings, the only requirement being an accurate layout or assembly drawing. It is estimated that a saving up to 75 per cent could be made in the production of drawings for prototypes and experimental models . . .

Advocates of simplified drafting insist that

. . . it is not a new concept of engineering drawing. It is merely the emphasizing of time-saving drawing techniques . . .

Is this emphasis, then, really the only thing that's new about simplified drafting? Not quite. The degree of short cutting—the simplified techniques themselves—must be recognized as new or, at least, different.

Those companies practicing simplified drafting to the fullest extent today have had first to develop a new book of rules. Drafting manuals have been rewritten and personnel trained in the preparation and interpretation of simplified drawings. These conditions and requirements are the things that are new about simplified drafting and are a large part of the current furor about the subject.

Why use simplified drafting?

Comments of companies using simplified drafting present the "pros" of the subject.

. . . we have recently completed work on a small design project that was handled on the basis of simplified drafting. We completed the work in 30 per cent less time than our original estimate despite the fact that the total number of drawings to be produced increased by 20 per cent . . . it is safe to assume that in the future we will be able to save better than 40 per cent of our design time through simplified drafting . . .

Although time saving seems assured by the new techniques, there seems to be no exact measure of how much might be saved.

. . . Many claims as to the time saved by simplified drafting have been presented. These saving estimates have ranged from 15 per cent to 65 per cent. Obviously the type of engineering work, and the extent to which simplified drafting is practiced, are the factors affecting the time saved . . .

Here is a typical expression of those who have investigated, and are beginning to apply, simplified drafting:

. . . we have long felt there are many advantages to be gained by reducing the amount of drawing time and, at the same time, simplify the appearance of drawings for the benefit of shop personnel . . . Although we are slightly sentimental about missing

Is it a new idea?

What are its advantages? Disadvantages?

Is there a middle ground?

What's the future of simplified drafting?

some of the beautiful works of art turned out by some of the fine draftsmen of yesterday, we are agreed that the rising costs in engineering departments are virtually forcing us to take steps, such as simplified drafting, to bring our budgets within proper levels . . .

What's wrong with simplified drafting?

From the viewpoint of the role of a drawing in a manufacturing organization, here's a thoughtful commentary that sums up the attitudes of many critics of simplified drafting:

. . . it must be recognized that most engineering departments tend to accumulate procedures and traditions which should be periodically subjected to a critical evaluation. This re-examination, necessary as it is, must not neglect the basic fact that a primary duty of any engineering department is the dissemination of pertinent information in readily understandable form.

Ultimate proof of the acceptability of an engineering drawing is the ease with which it can be correctly interpreted by the individual who will be required to reduce the engineer's lines and figures to a finished product. The desirability of reducing the costs of engineering drawings is not questioned, but if this is done at the expense of confusion, doubt or delay in a production department, the end result is the transferring of cost from overhead to production. The old rule of thumb that "one dollar on the drafting board saves ten dollars in the shop" should not be taken lightly.

True, circumstances may permit the use of simplified drawing techniques. If a development engineer has at his command the services of highly skilled mechanics, familiar with his methods, he should preferably use simplified sketches rather than conventional drawings to interpret his ideas. A job-shop engineer, working in close co-operation with production personnel, can and should develop such simplification of engineering information as befits the circumstances. These practices are not new. They are more common than uncommon but are seldom spotlighted by publicity.

Other circumstances seem to dictate the necessity for conventional engineering drawings. As an example, several years ago a custom pattern shop thought it advisable to inform the writer that they found it necessary to add 10 per cent to the estimated cost of any patterns drawn by one of his draftsmen who habitually used simplified drawing techniques.

The vanishing race of true journeyman machinists could be depended upon to "feel out" a drawing. The modern production worker must have a more carefully prepared drawing with enough views so that he can actually see the part from the drawing with a minimum of learning. The high-production shops may not require the production worker to use an engineering drawing but in many of the medium and low-production shops, the blueprint accompanies the lot, and the majority of the workers must take information from this print.

The production of spare parts for service requirements presents a different facet to the discussion. Usually a reputable firm furnishes spare parts for a mechanism of its manufacture for at least a decade after discontinuance. Usually the machining of spare parts for discontinued items must be done in an atmosphere of unfamiliarity. Where a simplified drawing might serve its purpose well in current production, once it becomes "cold" and separated from related items, this type of drawing could result in profound confusion. It would seem that, here, complete engineering drawings are mandatory . . .

Is there anything wrong with simplified drafting from other viewpoints?

. . . time used by drafting, design, or engineering can be wasted or saved in so many different ways that merely eliminating arrow heads or a few extra lines which are easy and quick "no-thinking" jobs seems a little futile. We can delay a project for a week or two by lack of enough preliminary layouts to work from or, perhaps, gain a couple of weeks by having the foresight to use revised duplicate tracings.

If the job at hand is to be made as an experimental project, freehand sketches, traced from the layout, can be used. The sketch sheets can be numbered ahead of time with EX or X numbers that will not be used later, and are used merely to identify the drawings. A good draftsman can throw out dozens of these sketches in a short time.

Perhaps one of the best time-savers in a drafting

room is a good draftsman. Many of us have seen poorly trained or inexperienced draftsmen, hired at lowest possible pay, make drawings that required complete redrawing, lowering the reputation of the engineering department and requiring so much supervisory time that the company would have been farther ahead by paying them to stay away.

There is much said about the importance of engineering; and quite often a draftsman is referred to as some sort of menial engineering department employee. A good many veterans with families, studying for an engineering career outside of working hours, are employed as draftsmen and may still be at it a few more years. Also, there are thousands of older men who earn their living as draftsmen. Why lower the prestige of these men and their chances for a good living by a narrow-minded "title-happy" approach? . . .

And here's a final shot from

. . . a young man, getting a little experience . . . I have put in over 52 years in drafting rooms, nearly half in supervising. A glance at simplified drafting is proof that instead of advancing up the next spiral of evolution we are reversing down a different one. It is incredible . . .

Is there a middle ground?

In this and many other discussions simplified drafting is debated as though it were all black or all white. But many companies have or are trying to find a satisfactory gray—a blend of the ultra-simplified and the conventional complete techniques. Here's one approach:

. . . we agree whole-heartedly with aims to simplify working drawings and with the scrapping of unnecessary classical trimmings. We have long been in need of the development of a "semantics" of the drawing board. However, we believe [that some simplified drafting standards] have gone so far that the drawing sometimes becomes confusing because of vagueness . . .

We have tried to work out a simplified system based on the belief that the average machinist is not too imaginative in his interpretation of drawings and should be shown the piece only as it looks to the naked eye on its various sides . . . In our drawings we try to adhere to the following:

1. Show minimum number of views absolutely required to convey desired information.
2. Show only visible and necessary edges, lines, etc.
3. Show no hidden lines, edges, holes, etc., unless absolutely essential for sake of clarity. No dotted lines. Show an additional view rather than clutter an existing view with dotted lines.
4. Dimensioning—Refer from real edges rather than imaginary center-lines, etc. Show information dimensionally in numbers rather than by notation. We have found that numbers are read more accurately than notations. Simple operations like countersinking or counterboring are drawn in as seen by the eye, but dimensioned by one arrow and notation. Keyways are handled the same way, as $\frac{1}{4}$ x $\frac{1}{8}$ keyway, with length dimensioned from a reference edge. We omit all pattern dimensions from machining drawings, except overall sizes, so as to identify the size of the piece.
5. Screw threads—Draw a picture of the thread profile in a free hand wiggly line, and indicate by an arrow, as $\frac{1}{2}$-13 Thd.
6. Chamfers—Avoid saying "break corners" for chamfers of approximately 0.010-inch by 45 degrees because the machinist is expected to do so without notation. If sharp corners are wanted, we indicate it so specifically. Larger chamfers are shown on the drawing, not necessarily to scale, but size and

A Typical Set of Rules for Simplified Drafting

1. Use description to eliminate delineation.
Example: Instead of a drawing of a sleeve or threaded stud, a satisfactory typewritten description of the article required may be made by a clerk.

2. Use description to eliminate projected views.
Example: Call for hex, square, or round stock instead of drawing another view. Show the thickness of a part on a plan view instead of a projected view.

3. Omit elaborate, pictorial, or repetitive detail.
Example: Use broken lines to represent outside diameter, pitch diameter, etc., of a gear instead of drawing the gear teeth. Instead of drawing the actual thread, use dotted lines or description.

4. Use keyed legend to indicate nuts, bolts and other hardware. Show outline only where necessary to indicate position.

5. Use dotted lines only to add clarification.

6. Use cross-sectioning only to add clarification.

7. Use symbols to indicate various hole sizes.

8. Avoid the use of hand lettering.

9. Avoid the use of arrow heads.

10. Use datum lines.

11. Make free-hand drawings where possible.

Under the motto, "A surplus line is a waste of time," these basic rules are proposed in *Simplified Drafting*, by J. H. Bergen, AMF Gen. Eng. Labs., 11 Bruce Place, Greenwich, Conn. Copies may be obtained from the author.

Also, techniques developed and practiced at International Harvester Co. have recently been described in *Machine Design:* "A Practical Approach to Simplified Drafting," P. Sammarco and A. G. Barows, August 1955, Pages 136-141.

The first basic reference in this subject is *Simplified Drafting Practice*, W. L. Healy and A. H. Rau, John Wiley & Sons, New York, 1953.

angle are indicated by arrow and notation.

Some of these procedures have evolved over a period of years of general job-shop experience with many different drawing systems, and an observation of the factors that caused the average machinist the most confusion. We have been quite successful with our own simplified system in reducing the number of mistakes made and in reducing machining costs . . .

Some companies that have not felt free to buy simplified drafting in its entirety have practiced various techniques having the same objectives. For example, one company suggests

. . . use of writing rather than printing for ordinary shop drawings. We have been following this practice for some 40 years or more, and while at first glance the drawing may not be as attractive as one on which printing is done, nevertheless writing is much faster for either the draftsman or the tracer. However, because of the difference in styles of writing, we have had to standardize writing style and teach our draftsman to write in a clear manner . . .

What's the future of simplified drafting?

The answer to this question seems to be supplied by the foregoing comments. Some companies will undoubtedly extend it on the basis of explorations that have proved successful *under certain circumstances.* Others cannot accept simplified drafting to the fullest extent for various reasons. Besides limiting influences already cited, here is another one mentioned by a British consulting-engineering firm:

. . . we are keenly interested in any new trends in drafting practice, and especially in simplification. This subject was also topical when a new British Standard Specification on drafting practice was introduced in this country about two years ago. Some simplifications were officially sanctioned in this standard, but since the subject is very controversial, the specification is rather guarded on this point. As it is our policy, as a firm, to adhere strictly to the various drafting procedures of each of our clients, we also find it difficult to introduce any appreciable amount of simplification . . .

If simplified drafting is to gain momentum and be practiced by any significant portion of industry, there seems to be another problem. Simplified drafting may

. . . become a boon to industry if it is intelligently presented. If this simplified method were to be used by the majority of industry, this would pose a problem—our present educational system teaches drafting as it has been taught for the last 50 years . . .

This issue will not be decided for some time to come. One professor of engineering drawing comments

. . . I am still inclined to feel that with the limited time available to us in most engineering drawing courses, and the large number of students with no drawing experience, we should teach the fundamental theory and leave it to each company to superimpose its own simplified procedures . . .

On the other hand, sponsors of simplified drafting report that several schools and universities have already begun to acquaint students with the new techniques.

Despite reasons why it won't work under some conditions, and problems that may have to be solved locally or generally, simplified drafting seems to be here to stay. Proof of time and money savings and evidence of adherence to drawing intent are substantial enough to promote continuing interest in, and growth of, simplified drafting.

Even part-way measures may offer advantages. Or, here's another way of looking at it:

. . . there is a need for different levels of pictorial communication, called drawings, just as we have different levels of written communication. There are the informal personal letter, the formal business letter, and the very formal legal contract. It is my belief that we have the same levels of need for the simplified drawing, the standard drawing, and the very well defined contract drawing suitable for large-quantity competitive procurement . . .

No company can afford to overlook the possibilities of simplified drafting. And none dare accept it without first carefully investigating the extent of its applicability.

ACKNOWLEDGEMENT

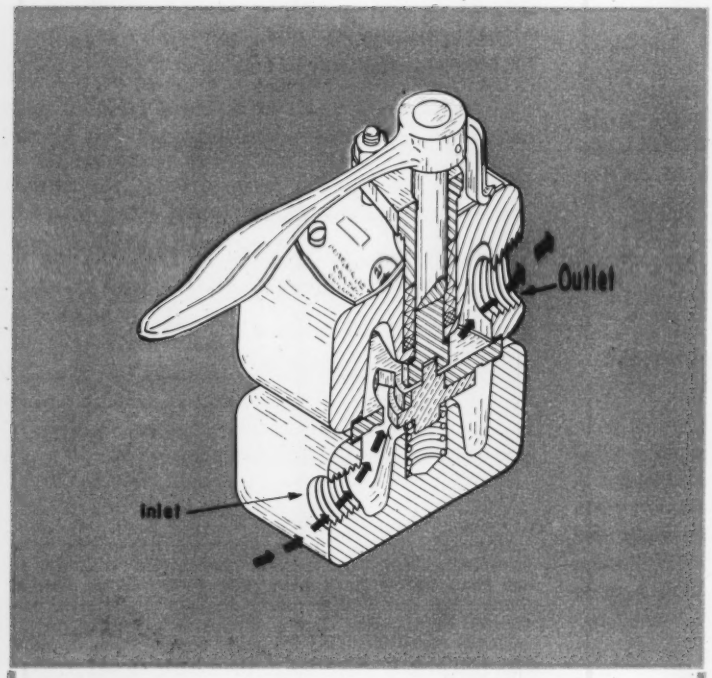
MACHINE DESIGN wishes to thank those men who contributed opinions to this discussion, whether or not their letters have been quoted here. Also, special thanks are due P. Sammarco and A. G. Barows, Advanced Engineering Dept., McCormick Works, International Harvester Co., for their co-operation in making available to MACHINE DESIGN some of the sources quoted in this article.

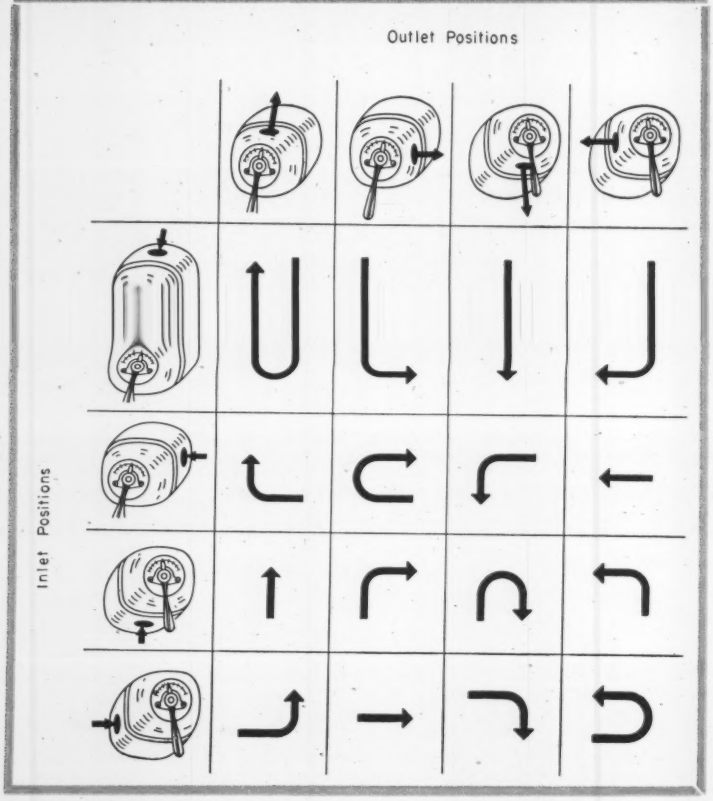
They Say . . .

"Many engineers in the past have overlooked the value of prestige to a professional group. It is prestige that has raised the professions of law and medicine to their present high state. Many historians today are predicting that engineering will ultimately achieve the highest level of prestige in future generations."—MURRAY D. VAN WAGGONER, *consulting engineer*

"Each engineer must realize that the primary responsibility for his development and advancement rests entirely upon himself. He must be competent in the details of his profession, have enthusiasm and interest for his assignment, and work for his opportunities. He must know how to accept, plan, and carry through an assignment from beginning to end. He must take inventory of his abilities and deficiences, and after evaluation, make a concentrated effort to develop and practice those qualifications which are lacking."—D. J. SIMMONS, *Consolidated Vultee Aircraft Corp., Fort Worth, Tex.*

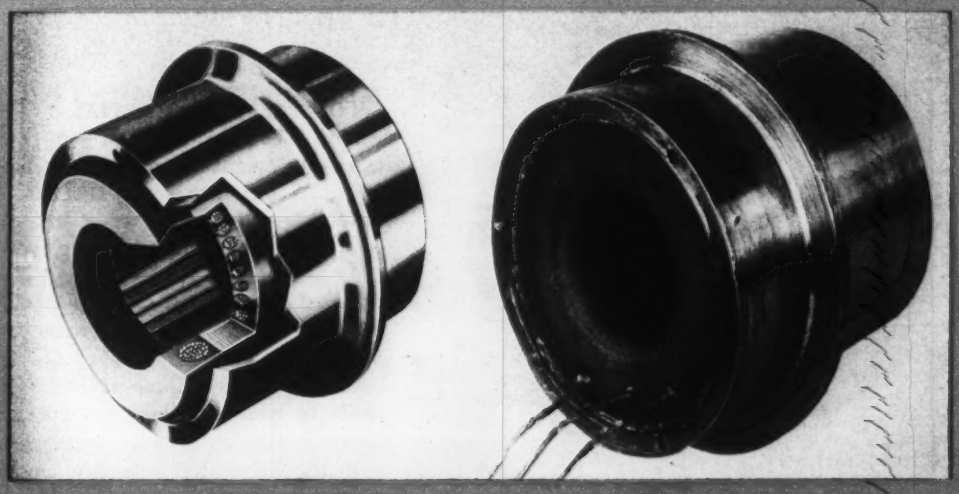
scanning the field for Ideas



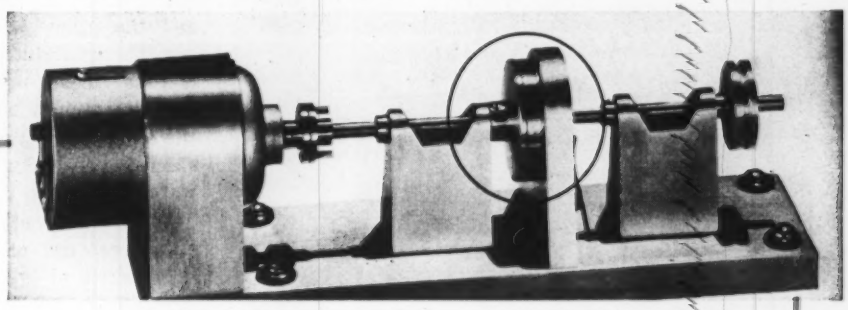


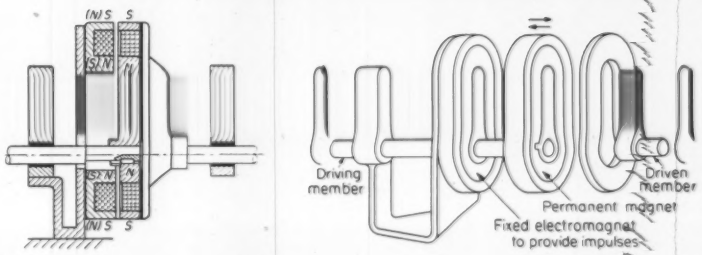
SPLIT-BODY VALVE construction makes possible 16 different inlet-outlet combinations in one flow-control unit. Built with an inlet in one half and an outlet in the other, the design permits easy disassembly and reassembly to form a different inlet-outlet arrangement.

Manufactured by the Automatic Temperature Control Co. Inc., for the National Aluminate Corp., the valve, forged from steel, does not leak at hydrostatic pressures as high as 2000 psi.

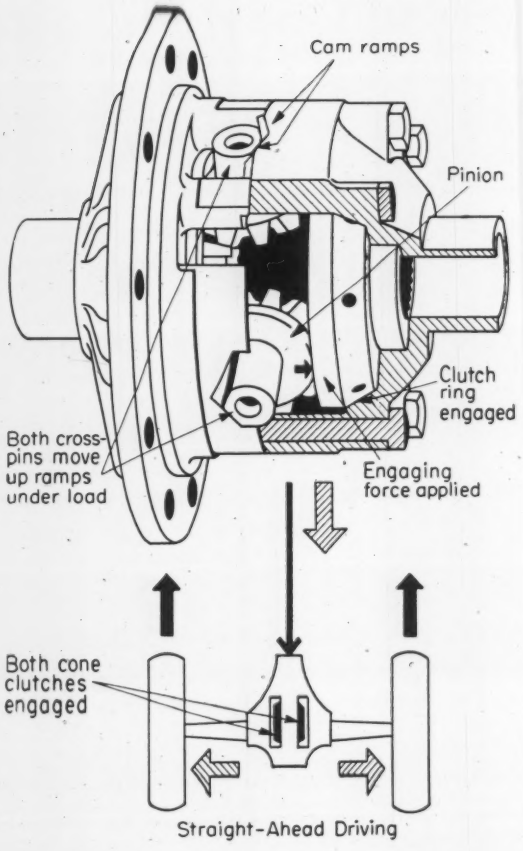


PLASTIC ENCASED WINDING in an electric motor permits operation in a pressurized atmosphere of inert gas under constant exposure to hot oil splash and vapor at temperatures over 200 F. In a special Electric Specialty ac motor the windings are cast in a high-temperature, chemical-resistant Kel-F fluorocarbon plastic to make a single, solid unit which is highly impervious to oil, acid, vapor and heat. Wire used in the windings is covered with either Teflon or glass.

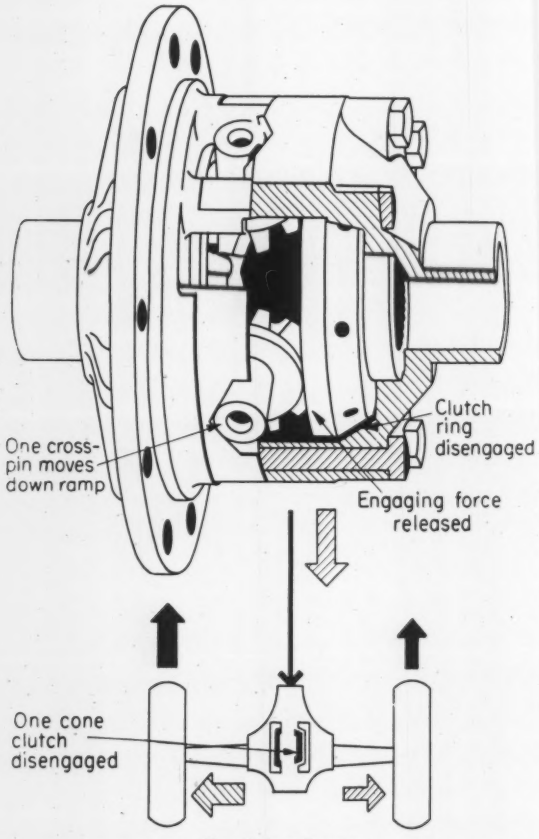




PERMANENT-MAGNET CLUTCH design does not require a continuous supply of electric current for its operation. Developed in Germany and manufactured by the Locke Machine Co., the clutch is engaged or disengaged by means of a momentary dc pulse to built-in electromagnets. Depending on polarity, the pulse either attracts the clutch members together or repels them apart. Electric pulse control of the clutch permits the unit to be battery powered.



Straight-Ahead Driving



Turning a Corner
(or Right Wheel Starting to Spin)

NONSLIP DIFFERENTIAL available in 1956 Packard line allows rear wheels to operate at different speeds on turns but acts somewhat like a solid axle under other conditions encountered in driving. Employing torque-bias or power-dividing differential design, the unit applies the most torque to the wheel with the most traction. It is designed not to send full engine torque to one axle shaft to eliminate the possibility of axle breakage.

In the differential assembly, clutch rings are splined to each axle shaft. These clutch rings are shaped to mate with clutch cone faces on the inside of the differential case. Torque from the engine is applied to the differential case through a ring gear in the conventional manner. The case transfers this torque to the differential pinion assembly through mating cam surfaces.

When wheel speeds are equal, the cam faces produce sidewise forces that press one pair of pinions to the left, engaging the left clutch, and the other pair to right engaging the right clutch. The differential is thus "locked-up," and the load is applied through both the clutch and the gear teeth. Cam surfaces are V-shaped, permitting operation in forward or reverse driving.

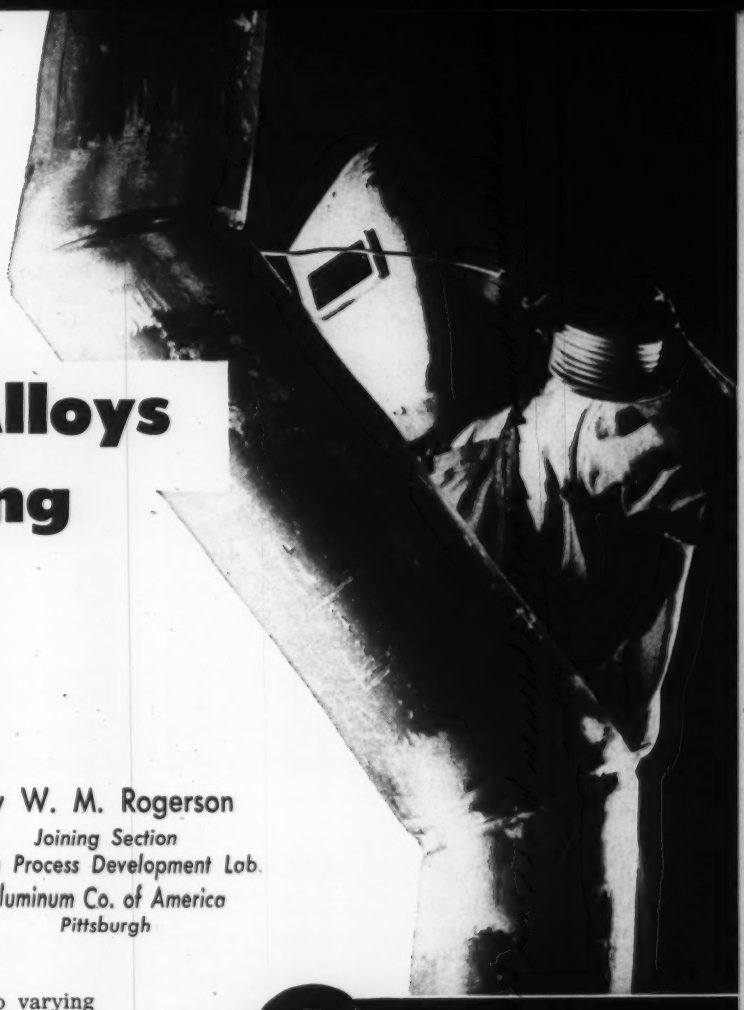
When differentiation is required, either because of turning a corner or one wheel spinning, the pinions driving the higher-speed axle drop down the cam ramp, releasing the clutch on that side. The axle shaft retaining traction continues to receive torque in a ratio between shafts that depends on the amount of friction in the differential and the amount of load being supplied to the differential.

Maximum allowable torque bias in this differential is 5 to 1; that is, the torque on the high-traction wheel is never more than five times the torque on the low-traction wheel. A higher ratio would be undesirable because of extra load on the high-traction axle shaft and possible adverse steering effects with a heavily concentrated driving force on one side.

Design considerations in selecting

Aluminum Alloys for Welding

Temper
Strength
Crack Sensitivity
Corrosion Resistance
Finish



By W. M. Rogerson
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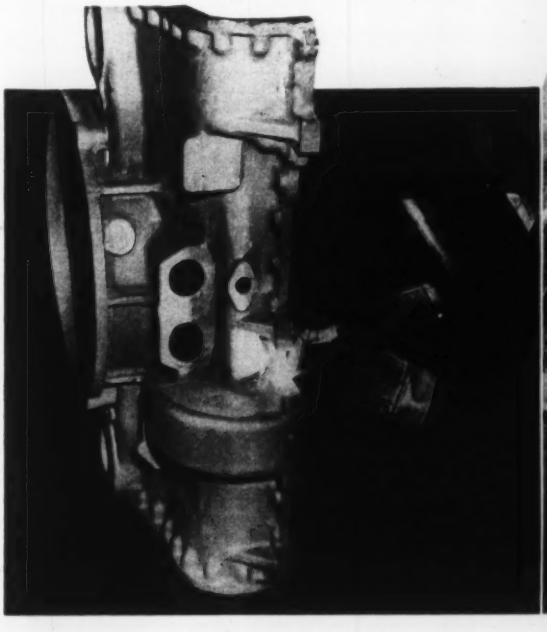
Pittsburgh

ALUMINUM and its alloys differ to varying degrees in their weldability. Pure aluminum and many of its alloys are readily weldable. Other alloys are not considered weldable, chiefly because of the strength-reducing effect of welding heat.

A number of typical successful applications of welded aluminum, *Table* 1, have been listed to enable the designer to make a direct comparison to



his proposed application or refer to a parallel service condition.

After an alloy for a particular welded assembly has been chosen by the general requirements, such as given in *Table* 1, the final choice is pin-pointed by a number of other factors. These include strength, crack sensitivity and corrosion resistance required. The finish to be used on the completed product is also an important factor.

Effect of Temper: Aluminum alloys may be classified as (1) an alloy that can be heat treated to improve hardness and strength, and (2) an alloy that is not heat treatable but whose temper and strength can be controlled over a wide range by cold working. Temper or hardness of an alloy can affect its formability and can be a material factor in its serviceability, but it has little effect on weldability. An exception to this rule is resistance welding (spot and seam), which can be best accomplished on harder tempers.

Strength Considerations: The prime consideration in the selection of an aluminum alloy for welding is the strength requirement of the end product. Most aluminum alloys can be welded, but the strengths of the alloys cover a comparatively wide range.

A good comparison of the welded strengths of aluminum alloys in general is provided in *Table* 2. It will be noted that aluminum-magnesium alloys 5056 and X5356 provide somewhat higher strengths than the newer 5154. Reason for the wide use of 5154 lies in its low cost.

When maximum strength in an aluminum weldment must be achieved using extrusions, rolled shapes or forgings, a strong heat treatable alloy like 6061-T6 is usually employed. This alloy can also be used in weldments as sheet and plate. It has higher inherent strength in the -T6 temper but it loses much of this strength across the weld because of the annealing action of the weld heat.

The use of heat-treatable alloys generally is avoided if a nonheat-treatable alloy will do the job. The reason for this practice is that the heat of welding tends to reduce the strength across the weld, especially with torch welding. Careful control of welding process will avoid some of this strength loss. Heat treatment after welding may also restore strength.

Crack Sensitivity: Adding alloying constituents to aluminum affects the range in which the alloy melts. In some instances, the alloy develops hot shortness in the melting range. This condition has some influence on the tendency of a welded joint to crack during solidification.*

Stresses that influence weld cracking can be controlled by (1) proper joint location, (2) proper joint preparation and selection of proper filler alloy, *Table* 3, and (3) choice of welding process.

Welding by the consumable-electrode process can be conducted very rapidly with minimum contraction stresses developing. Tungsten arc weld-

*J. D. Dowd—"Weld Cracking of Aluminum Alloys," *Welding Journal Research supplement*, October, 1952.

Table 1—Typical Applications of Aluminum Alloys for Welded Construction

Field of Application	Alloy No.
Welded pipe lines	3003, Alclad 3003 6063 6061
Welded machinery parts, gasoline and diesel engine bases, booms and scaffolding	6061 5154
Ship structures	5154 X5356 6061
Cooking utensils	1100 3003, Alclad 3003 5005 5052
Gasoline truck tanks	3003 5052 5154
Vessels for handling hydrogen peroxide (Tanks, drums, tank cars, piping)	1160 5652 5254 6063
Vessels for handling ammonium nitrate	3003, Alclad 3003 5052 5154[1]
Architectural	4043 4543 6061 6062 6063
Furniture	6061 6062 6063
Beer barrels	Alclad 6053
Brewery tanks, piping, equipment	1160 3003, Alclad 3003
Water tanks—cold or hot —distilled	Alclad 3003 Alclad 6061
Tank supports, external stiffeners, stair structure, brackets, etc.	6061

1. For applications where temperature is less than 150 F.

Table 2—Strength and Ductility of Welded Butt Joints*

Alloy		Min Tensile Strength Parent Material		Avg Tensile Strength Across Weld	Avg Free Bend Elongation
Parent Material	Filler Wire	Annealed (1000 psi)	Heat-Treated (1000 psi)	(1000 psi)	(per cent)
Non-Heat-Treatable Alloys					
1100	1100	11	..	13.4	54
3003	1100	14	..	16	58
3004	3004	23	..	27.5	26
5052	5052	25	..	28.2	39
5154	5154	30	..	33.3	39
5056	5056	35	..	38.3	31
X5356	X5356	35	..	40.2	34
Heat-Treatable Alloys†					
2014-T6	4043	..	64	33.9	9
6061-T6	4043	..	42	27.2	16
6062-T6	4043	..	42	27.2	16
6063-T5	4043	..	22	20	..
6063-T6	4043	..	32	20	..
6063-T83	4043	..	33	20	..
6063-T831	4043	..	28	20	..
6063-T832	4043	..	40	20	..
Heat-Treatable Alloys‡					
2014-T6	4043	..	64	51.5	5
6061-T6	4043	..	42	43.5	11
6062-T6	4043	..	42	43.5	11

*Made by the argon-shielded tungsten arc or the argon-shielded consumable-electrode method.
†Not heat treated after welding.
‡Heat treated and aged after welding.

ing is also good in concentrating heat and thus reducing metal expansion and resulting contraction stresses. Torch welding is unsatisfactory where there is danger of cracking because the large volume of metal heated during the operation causes excessive expansion with the result that severe contraction stresses arise as the weld area cools.

Corrosion Resistance: Many of the standard aluminum alloys can be welded without decreasing the corrosion resistance of the assembly. Generally, the welding method does not influence resistance to corrosion.

Problems that may arise in equipment for handling chemicals or process materials are likely to be complex. In such environments, minor differences of materials and techniques can result in greatly exaggerated performance differences. Each of these situations requires special attention.

Corrosion resistance of nonheat-treatable alloys is not usually changed appreciably by welding. Among the alloys that can be welded without much effect on their resistance to attack are 1100 and alloys like 3003, 3004, 5050, 5154, 6061, 6063, and cast alloys 43, 355 and 356. Welded combinations of these alloys also have good resistance to corrosion.

Heat-treatable alloys containing substantial amounts of copper, such as 2014, 2017, and 2024, usually have their inherent resistance to corrosion lowered by welding. Along with their strength, most of their resistance to corrosion can be restored if it is practicable to heat treat the assembly after welding.

The resistance to corrosion of 2014-T6, 2024-T6 and 2024-T8 (artificially aged) is less affected by welding than that of 2014-T4 and 2024-T4 (naturally aged). Painting serves to prevent attack as long as paint coatings are adequately maintained and serviced.

Table 3—Welding Filler Alloys

Alloy No.	Application
1100 (2S)	For welding 1100 (2S) and 3003 (3S) parent metals, good color match for subsequent anodizing; good ductility; tensile strength weld area 12,000 to 15,000 psi.
4043 (43S)	General purpose for all weldable aluminum alloys; weld metal dark color when anodized; weld strength varies with parent metal and with method of heat treatment; tensile strength weld area 12,000 to 30,000 psi.
5154 (A54S)	For welding 3004 (4S), 5052 (52S), 5154 (A54S) parent metals; high as-welded strength and ductility; tensile strength weld area up to 30,000 psi; also for special applications with 6061 (61S), 6062 (62S), and 6063 (63S) parent metals; color match when anodically coated suitable for most applications.
5356 (XC56S)	For inert-gas arc welding all weldable aluminum alloys except 1100 (2S) and 3003 (3S); better fluidity, ductility and higher strength than 5154 (54S); tensile strength weld metal up to 42,000 psi; excellent color match when anodized.
142, 195, 355, 356	For gas or tungsten arc welding castings of similar parent metals.

Alclad aluminum alloys, as welded, show better resistance to corrosion than corresponding nonclad alloys welded in the same way. Both the core alloy and the exposed welded zone are electrochemically protected by the more anodic cladding.

Typical alloys used are Alclad 3003 and Alclad 3004. Although experience with Alclad 2014, Alclad 2024 and Alclad 7075 is limited, the same generality holds true for these heat-treatable alloys. Exposure tests indicate that welding reduces the corrosion resistance of the latter three alloys. However, considerable improvement can be obtained by heat treating after welding.

Filler metal of commonly used alloys like 1100, 4043, 5154 and 356 displays good inherent resistance to corrosion. High-purity aluminum is often preferred for environments involving corrosive chemicals.

Aluminum-magnesium alloys used for filler material are highly resistant to corrosion. However, they tend to be anodic to most other aluminum alloys and will thus be the sacrificial material in the event of galvanic corrosion. For this reason, they should be used with caution whenever the environment may subject the weld and parent metal to galvanic attack. Situations such as possible immersion in electrolytes should always be considered.

Selection of Alloy for Alumilite Finish: Another consideration—and one that may influence the choice of alloy—is the color difference of weld zones on parts that are to be Alumilite-finished. This finishing method produces apparent color changes in and near the weld zone. Occasionally such differences are objectionable.

Least contrast between the weld zone and parent metal after Alumilite finishing is obtained with the nonheat-treatable wrought alloys. Heat-treatable alloys 6061, 6062 and 6063, frequently used in architectural work, are often Alumilite finished. Welding heat causes precipitation of alloying constituents in these alloys. Thus, after Alumilite finishing, the heat-affected area may exhibit a different appearance near each welded joint. This color difference can be minimized by solution heat treatment of the parts to redissolve constituents after welding. This operation is costly and is frequently impractical.

In many instances, other means of controlling the extent and severity of the discoloration may be employed.

Welding method has some effect. Experience has shown that the weld metal in joints made by torch welding, metal arc welding or inert-gas shielded arc welding appear about the same after Alumilite finishing.

Inert-gas shielded arc welded joints generally minimize the "halo" or staining effect near the weld zone. Arc welding deposits metal rapidly within a narrow heat-affected area. Arc welding or torch brazing results in less discoloration than torch welding.

Flash butt welding makes the narrowest weld

zone and results in the least discoloration caused by rise of metal temperature near the weld. Welds made by this method show a narrow line at the joint that nearly matches the parent metal. Equipment and machine setups for making flash welds are relatively expensive and use of the process is limited to production of large numbers of similar pieces.

Mechanical finish affects discoloration. Coarser mechanical finishes lessen color differences on Alumilite finished welded parts. A sand-belt or steel-wool finish is much better than buffed or polished finishes.

Welding wire composition has a definite effect on the color matching between welds and parent metal. For instance, welds made with 1100 or 5154 filler wire are about the same color as 6061, 6062 or 6063. Some contrast between the weld and parent metal shows, however, because the cast metal in the weld has a different texture from the wrought parent metal.

Similar results can be obtained by employing strips of parent metal as filler wire, but this may lead to difficulty from cracking. A preliminary trial is advisable to determine whether the parent composition will work out as a filler material in each case.

The color of Alumilite finish on a weld made with 4043 wire is dark gray as compared with the parent metal. Consequently, 4043 filler shows a greater contrast in color than the alloys mentioned in the previous paragraph. Torch brazed joints are made with No. 718 brazing wire, which, like 4043, is a silicon alloy. This material also turns dark gray upon Alumilite finishing. In the case of brazing, however, as contrasted with welding, the parent metal is not melted when the joint is made. When the excess metal is removed, only a regular, narrow line of filler metal appears on the surface. The appearance of this line is not usually objectionable.

Weld bead location can often be changed to afford both satisfactory joint strength and freedom from discoloration. The weld can often be made from the back or under side of the assembly by the metal arc process, inert-gas shielded arc process, or by torch brazing.

If equipment for all three methods is available, the best recommendation would be inert-gas shielded arc welding. Next best would be torch brazing, since this reduces the chance of melting the base metal or "burning through." Wide distribution of temperature usually eliminates the staining or "halo" effect. Torch welds, on the other hand, when made from the under side, result in discoloration of the top surface.

Thickness of the parts affects the speed of welding and, consequently, the distribution of heat during welding. Generally, thin parts can be welded more readily in shorter time periods and with less discoloration than heavy parts of similar alloy and temper.

Choosing Welding Method: Most standard methods of welding, brazing and soldering may be employed for joining aluminum parts. Each method has some limits of application and a specific job may dictate the process to use. There is, however, much overlapping in fields of application for the various processes.

Spot and seam welding are applied only to lap joints in any alloy and generally on thicknesses not greater than ⅛-inch.

Torch welding should be used only on low-strength light-gage alloys and only where the residual welding flux can be removed entirely from completed work.

Consumable-electrode welding and tungsten arc welding processes have a wide field of application and can generally be used without reservations except those concerning the heat effect on material strength.

Recommended Aluminum Alloys Conforming To Commonly Used Codes and Specifications

Code or Specification	Alloy No.
ASME—Unfired Pressure Vessels	1160
API—Storage Tanks	1100 3003, Alclad 3003 3004, Alclad 3004 5005 5052 5154 6061, Alclad 6061 6063 6151 Castings—None
ASCE—Moderate Strength Aluminum Alloy Structures, Part III, Vol. 78, Separate No. 132	6061
AAR—Tank Cars, Spec. No. 201A-35W	1100 3003 6061
ICC—Regulations for Transportation of explosives and other dangerous materials by land or water in rail freight service, by motor vehicle (highway) and water including specifications for shipping containers. Tank car specification 104-A-A1-W; 105-A-300-A1-W	1100 3003 5052 5652 5154 5254
ASA—Pressure Piping, B31.1a, 1953, Supplement No. 1	3003

They Say . . .

"Never before in history has the engineering profession faced so many vital problems as it is encountering today. The new materials and devices rapidly developing for the armed forces, almost without exception, will find their usefulness in normal peacetime production. The demand of the public for improved standards of living, together with the recognition of the need to aid less fortunate people, is throwing a burden on the engineering profession not felt by previous generations."—DR. MAYNARD M. BORING, *president, American Society for Engineering Education*

Design equations and nomographs for self-energizing types of

SPRING CLUTCHES

By Joseph Kaplan and Donald Marshall

Project Engineer
Bulova Research and Development Lab. Inc.
Woodside, N. Y.

Analytical Design Engineer
Fairchild Engine and Airplane Corp.
Deer Park, N. Y.

THE SPRING override clutch is perhaps the simplest device for transmitting a torque in one direction and overriding or slipping in the other direction. In its simplest form this clutch consists of two coaxial drums bridged by a helical coil spring, *Fig.* 1. The spring is not fastened to either drum.

Operating Theory: The principle of operation depends entirely upon radial force combined with the coefficient of friction between the spring and the drums. The necessary radial force is developed by so winding the spring that its inside diameter is smaller than the diameter of the driving and driven drums. When the spring is mounted, it has "diametral squeeze." The diametral squeeze and coefficient of friction cause the spring wire to grip both drums. In the driving direction the spring tends to coil more tightly and increase its grip on the driving and driven drums, thereby transmitting the torque. When the driving direction is reversed this same grip tends to uncoil the spring and expand it. As the spring expands, the radial force is decreased thereby allowing the clutch to slip and override.

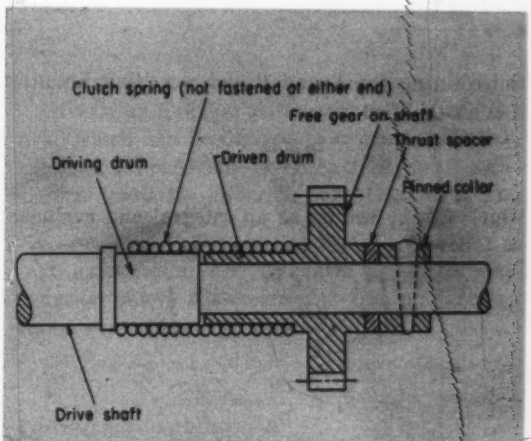


Fig. 1—Typical overrunning spring clutch application. In the drive direction relative rotation between drums automatically causes the spring to contract and tightly grip the drums. Relative rotation in the opposite direction releases the spring grip permitting overrunning

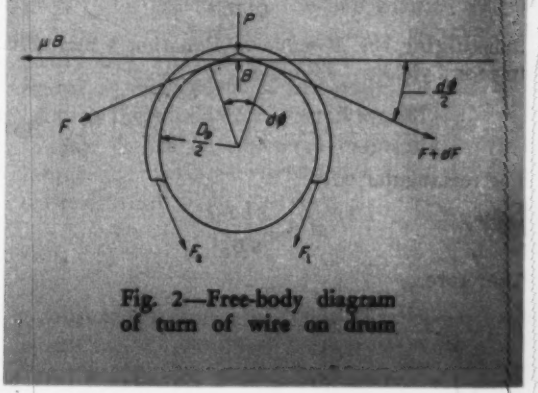


Fig. 2—Free-body diagram of turn of wire on drum

Design Parameters: To design a spring clutch it is necessary to establish the design parameters which are, in general, (1) torque capacity in the driving direction and (2) a minimum of frictional drag in the overriding direction.

To carry the driving torque, and yet override freely with a minimum of frictional torque, the spring wire must be highly stressed. Obviously, the design parameters previously stated are overlapping. This produces interdependent equations which have somewhat lengthy solutions. Therefore, graphical solutions of the principal design equations are included in this article. Design limits, which chosen arbitrarily but found advisable, are a minimum of 5 and a maximum of 10 turns of

wire per drum. Data are provided for spring override clutches designed with wire having either round, rectangular or square cross-section.

Diametral Squeeze: From the free-body diagram, *Fig.* 2, the following equilibrium equations are established:

$$B - P - F \sin \frac{d\phi}{2} - (F + dF) \sin \frac{d\phi}{2} = 0 \quad (1)$$

where $\Sigma F_V = 0$, and

$$(F + dF) \cos \frac{d\phi}{2} - F \cos \frac{d\phi}{2} - \mu B = 0 \quad (2)$$

where $\Sigma F_H = 0$.
Therefore, the reaction force is

$$B = \frac{dF \cos \frac{d\phi}{2}}{\mu}$$

The gripping force due to diametral squeeze of the spring P can be expressed as

$$P = \frac{2M\,d\phi}{D_D} \quad (3)$$

Substituting for B and P and rewriting Equation 1 in a simplified form,

$$dF - \frac{2\mu M d\phi}{D_D} - \mu F d\phi = 0$$

which can be set up as an integral and evaluated as follows:

$$\int_{F_2}^{F_1} \frac{dF}{\frac{2M}{D_D} + F} = \mu \int_0^{\phi} d\phi$$

$$F_1 + \frac{2M}{D_D} = \frac{2Me^{\mu\phi}}{D_D}$$

for $F_2 = 0$. Since $T = FD_D/2$, the transmission capacity of a clutch spring is

$$T = M(e^{\mu\phi} - 1) \quad (4)$$

This equation shows the transmission torque is a function of the moment in the wire M, the coefficient of friction μ and the angle of wrap per drum ϕ. This is true within the limits of the yield stress for the wire.

For round wire the moment can be expressed as

$$M = \frac{\pi E D_W^4 \delta}{32 D_D^2}$$

Substituting the M value in Equation 4 and solving for δ yield

$$\delta = \frac{32 D_D^2 T}{\pi E D_W^4 (e^{\mu\phi} - 1)} \quad (5)$$

For rectangular wire

$$M = \frac{E b t^3 \delta}{6 D_D^2}$$

Therefore,

$$\delta = \frac{6 D_D^2 T}{E b t^3 (e^{\mu\phi} - 1)} \quad (6)$$

Since for square wire $b = t$, Equation 6 may be modified to the form

$$\delta = \frac{6 D_D^2 T}{E t^4 (e^{\mu\phi} - 1)} \quad (7)$$

Nomographic solutions of δ in Equation 5 may be obtained from the alignment chart in *Fig.* 3. This nomograph is based on seven turns of round steel wire per drum and on the minimum diametral interference required to transmit a design torque. From *Fig.* 3 diametral interference may be obtained for three coefficients of friction: $\mu = 0.05$ (running in oil), $\mu = 0.1$ (slightly oily) and $\mu = 0.15$ (dry). Although the chart in *Fig.* 3 is based on 7 turns of wire per drum, values of δ obtained from this nomograph may be modified for other numbers of turns per drum by the multiplying factors given in *Table* 1. These multiplying factors are based upon the effects of changes in the angle-of-wrap term, $e^{\mu\phi}$, in Equations 5, 6 and 7. Values of $e^{\mu\phi}$ are listed

Nomenclature

- A = Cross-sectional area of wire, sq in.
- B = Shaft reaction force, lb
- b = Width of rectangular wire, in.
- D_D = Diameter of drum, in.
- D_W = Diameter of wire, in.
- E = Modulus of elasticity, psi
- F = Pull of wire, lb
- $I\mu$ = Friction torque, lb-in.
- K = Wahl factor
- M = Moment of spring, lb-in.
- N = Minimum number of coils per drum
- P = Gripping force of spring, lb
- s = Maximum stress in wire, psi
- s_b = Bending stress in wire, psi
- s_t = Tensile stress in wire, psi
- T = Transmitted torque, lb-in.
- t = Thickness of rectangular wire, in.
- δ = Diametral interference, in.
- $\Delta\delta$ = Diametral interference increment to overcome centrifugal effects, in.
- μ = Coefficient of friction
- ρ = Density of wire, lb per cu in.
- ϕ = Angle of wrap of spring wire per drum, radians
- ω = Angular speed, radians per second

Table 1—Diametral Interference

Turns of Wire per Drum	Multiplying Factors μ=0.05	μ=0.1	μ=0.15
5	2.10	3.62	6.58
6	1.43	1.88	2.56
7	1.00	1.00	1.00
8	0.70	0.53	0.38
9	0.50	0.28	0.15
10	0.36	0.15	0.057

Use multiplying factors to correct values of diametral interference obtained from nomograph in *Fig.* 3.

in *Table* 2 for friction values of 0.05, 0.1, 0.15 and 0.2, and number of turns per drum from 5 to 10, inclusive.

Wire Stresses: Obviously, the wire used in the design of a spring override clutch must withstand maximum stress that it will encounter. The maximum stress in the wire occurs in the bridging coil between the driving and driven drums. Its value is the summation of the stresses developed in bending the wire over the drums, s_b, and the tensile stress, s_t, caused by the driving torque or

$$s = s_b + s_t \quad \ldots\ldots (8)$$

For round wire the formula for bending stress is

$$s_b = \frac{K E D_W \delta}{D_D^2} \quad \ldots\ldots (9)$$

and a nomographic solution of this equation is presented in *Fig.* 4. The formula for rectangular or square wire of thickness t is

$$s_b = \frac{K E t \delta}{D_D^2} \quad \ldots\ldots (10)$$

and the *Fig.* 4 nomograph may be used to solve this expression by using t values on the D_W scale.

The formula for tensile stress for round wire is

$$s_t = \frac{8 T}{\pi D_W^2 D_D} \quad \ldots\ldots (11)$$

Tensile stress in rectangular wire is

$$s_t = \frac{2 T}{b t D_D} \quad \ldots\ldots (12)$$

In the case of square wire, since $b = t$, tensile stress is simply

$$s_t = \frac{2 T}{t^2 D_D} \quad \ldots\ldots (13)$$

The nomograph in *Fig.* 5 may be employed to find tensile stress in square wire using values of t on the D_W-scale and multiplying the value of tensile stress s_t found by 0.785.

In the charts in *Figs.* 3, 4, and 5 the wire is assumed to be steel with E = 30,000,000 psi and the Wahl factor K = 1.05.

Centrifugal Effects: In Equation 5 the diametral interference required to transmit a given torque has been established. This expression, derived for static conditions, will apply for low and medium speeds. For high speeds and large drum diameters the centrifugal force tends to expand the spring and reduce the diametral interference. If this effect becomes pronounced, the clutch may not be able to transmit the design torque capacity of the spring. To counteract centrifugal force a small additional diametral interference may be initially applied. For round wire

$$\Delta\delta = \frac{2 \rho D_D^5 \omega^2}{E D_W^2} \quad \ldots\ldots (14)$$

and for rectangular and square wire of thickness t

$$\Delta\delta = \frac{1.5 \rho D_D^5 \omega^2}{E t^2} \quad \ldots\ldots (15)$$

Equations 14 and 15 have been derived for the maximum moment in the wire caused by the location of its mass in the centrifugal field. The maximum moment occurs 180 degrees away from the free end of the spring and is given by

$$M = \frac{\rho D_D^3 A \omega^2}{4}$$

Overriding Friction Torque: The following equation, which can be derived in a manner similar to the torque capacity expression given in Equation 4, gives the overriding friction torque of a clutch spring:

$$T_s = M (e^{\mu\phi} - 1)$$

A substitution for M values in the preceding equation shows the overriding friction torque for round wire to be

$$T_s = \frac{\pi E D_W^4 \delta_{max} (e^{-\mu\phi} - 1)}{32 D_D^2} \quad \ldots\ldots (16)$$

For rectangular wire

$$T_s = \frac{E b t^3 \delta_{max} (e^{-\mu\phi} - 1)}{6 D_D^2} \quad \ldots\ldots (17)$$

and for square wire, since $b = t$,

$$T_s = \frac{E t^4 \delta_{max} (e^{-\mu\phi} - 1)}{6 D_D^2} \quad \ldots\ldots (18)$$

For most clutches $e^{-\mu\phi}$ is a small quantity. Therefore, for all practical purposes the friction torque is equal to the interference moment, or $T_s = -M$. Consequently $e^{-\mu\phi}$ can be omitted from Equations 16, 17 and 18 with only slight error. For instance, if $\mu\phi = 4$, the deviation is less than 2 per cent, and for $\mu\phi = 5$, it is less than 1 per cent. An oddity here is that the maximum value for friction torque is independent of the coefficient of friction between the wire and the drums since $T_s = -M$.

Also, T_s can be expressed in terms of driving torque. By using values in *Table* 2 for $e^{\mu\phi}$ a good approximate T value is given by

$$T_s \simeq \frac{T}{e^{\mu\phi} - 1} \quad \ldots\ldots (19)$$

Example: Assume the following conditions must be met in the design of a spring override clutch. The diameter of the drum, D_D = 0.75-inch; the

Table 2—Spring-Wire Friction Wrap Factors

Angle of Wrap per Drum (turns)	ϕ (radians)	$e^{\mu\phi}$ μ=0.05	μ=0.1	μ=0.15	μ=0.2
5	10π	4.8	23	111	530
6	12π	6.6	43	283	1880
7	14π	9.0	81	725	6500
8	16π	12.3	151	1880	22,800
9	18π	16.9	283	4800	80,000
10	20π	23.0	530	12,200	280,000

required torque capacity, T = 4 lb-in.; the friction surfaces will be slightly oily so that the assumed friction value, μ = 0.1; and the maximum working stress in the wire is 90,000 psi which is close to the value of yield stress. Assume the wire is made of steel and is round, and seven turns per drum are used in the design.

As a start, try $D_W = D_D/20$ or, in this case, 0.037-inch. In the nomograph in *Fig.* 3 draw a straight line across the turning axis and through the points D_W = 0.037-inch and D_D = 0.75-inch. From the intersection of this line on the turning axis and the point on T-scale that equals 4 lb-in., draw a straight line and read δ = 0.005-inch. Since the nomograph is based upon 7 turns per drum, no correction of δ from *Table* 1 is required.

From the nomograph in *Fig.* 4, the bending stress in the wire may be found. Draw a straight line across the turning axis and through the points D_D = 0.75-inch and D_W = 0.037-inch. From the intersection of this line on the turning axis and the point on the δ-scale that equals 0.005-inch, draw a straight line and read s_b = 10,000 psi.

Similarly, tensile stress in the wire may be found by use of the nomograph in *Fig.* 5. Draw a straight line across the turning axis and through the points D_W = 0.037-inch and D_D = 0.75-inch. From the intersection of this line on the turning axis and the point on the T-scale that equals 4 lb-in., draw a straight line and read 9,500 psi.

From Equation 8, s = 10,000 +9,500 = 19,500 psi which is too far below the allowable working stress.

Following a similar procedure and trying $D_W = D_D/30$ = 0.025-inch give δ = 0.023-inch from *Fig.* 3, s_b = 33,000 psi from *Fig.* 4, and s_t = 22,000 psi from *Fig.* 5. Thus, s = 33,000 + 22,000 = 55,000 which is still too far below 90,000 psi.

A third try using $D_W = D_D/35$ = 0.022-inch gives δ = 0.040-inch, s_b = 50,000 and s_t = 28,000. These values of s_b and s_t provide an s = 50,000 + 28,000 = 78,000 psi. This stress value appears to be satisfactory, but the overriding frictional torque should be checked next.

If it is assumed that accumulated tolerances are equal to 0.010-inch in the tight direction, then δ_{max} = 0.040 + 0.010 = 0.050-inch. From the nomograph in *Fig.* 3, this value of δ_{max} gives T = 5 lb-in. for D_W = 0.022-inch and D_D = 0.75-inch. This value of T substituted in Equation 19 shows that the overriding frictional torque, $T_s \approx 5/(81-1) = 0.0625$ lb-in. The value of $e^{\mu\theta} = 81$ is taken from *Table* 2 for 7 turns per drum and μ = 0.1.

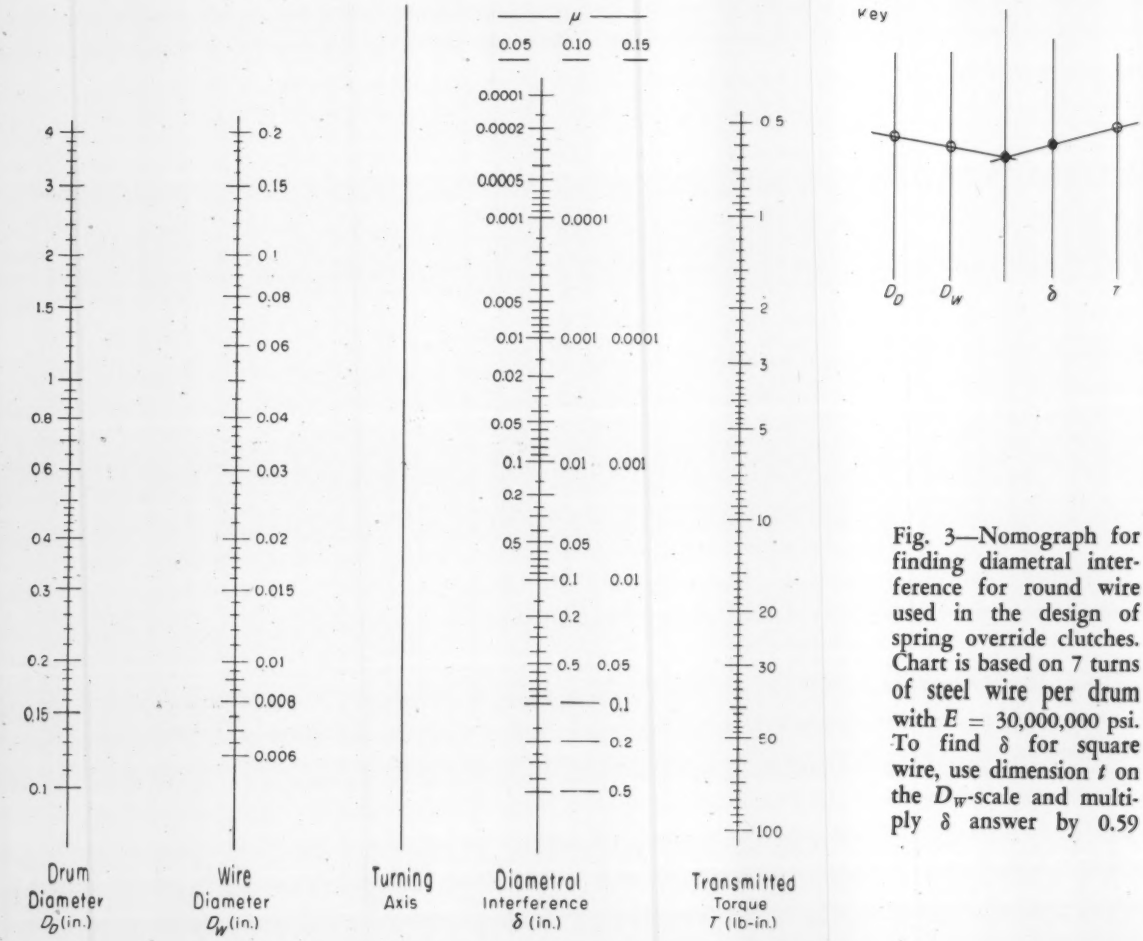


Fig. 3—Nomograph for finding diametral interference for round wire used in the design of spring override clutches. Chart is based on 7 turns of steel wire per drum with E = 30,000,000 psi. To find δ for square wire, use dimension t on the D_W-scale and multiply δ answer by 0.59

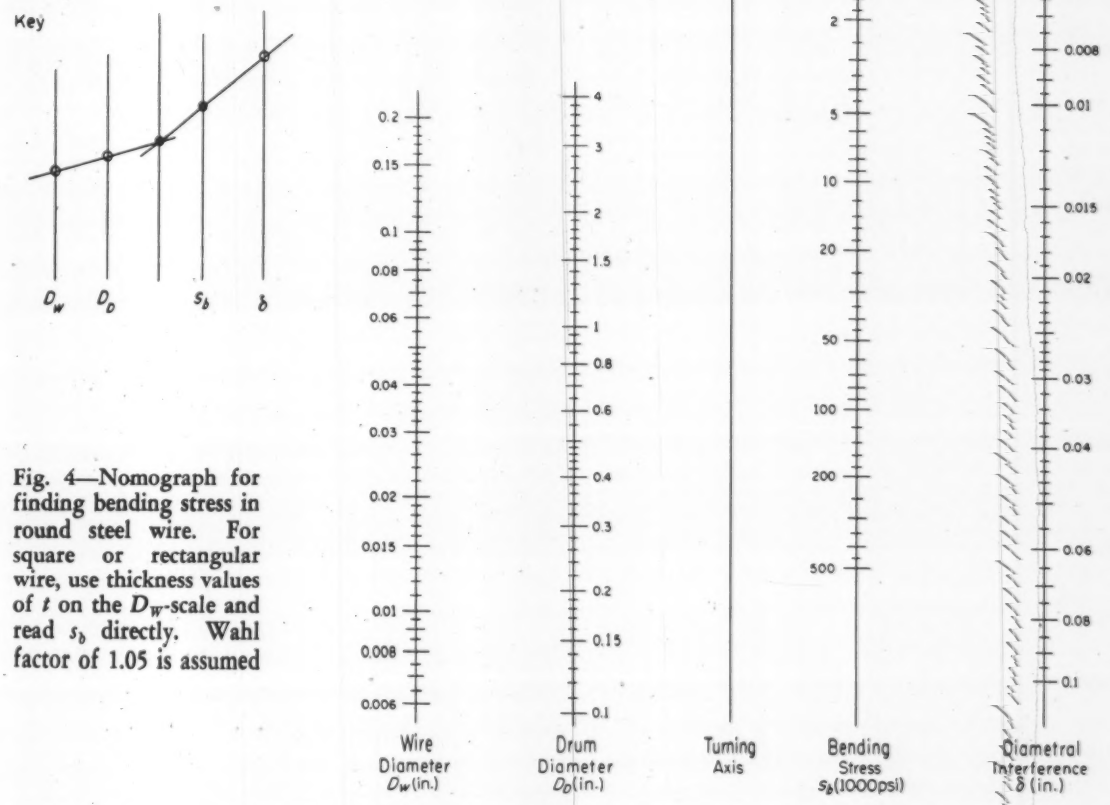


Fig. 4—Nomograph for finding bending stress in round steel wire. For square or rectangular wire, use thickness values of t on the D_w-scale and read s_b directly. Wahl factor of 1.05 is assumed

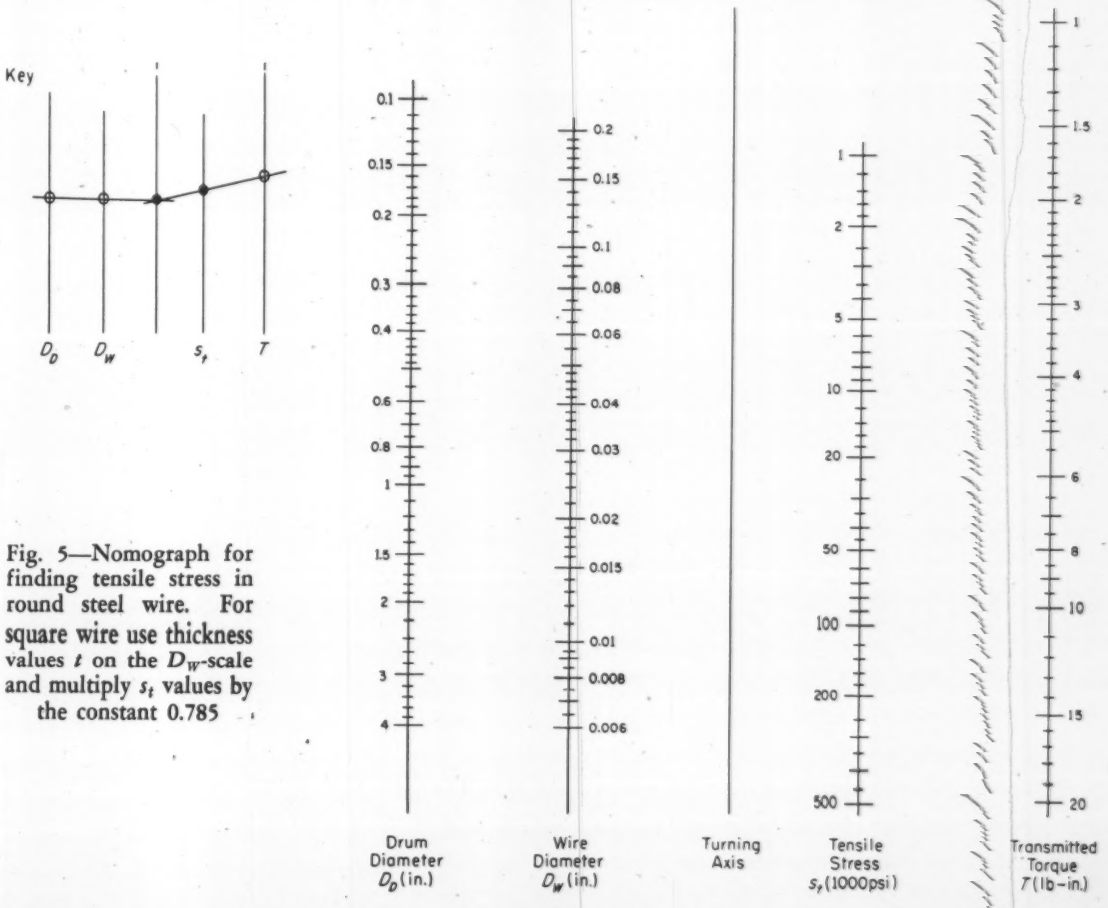


Fig. 5—Nomograph for finding tensile stress in round steel wire. For square wire use thickness values t on the D_w-scale and multiply s_t values by the constant 0.785

DIMENSION CONTROL

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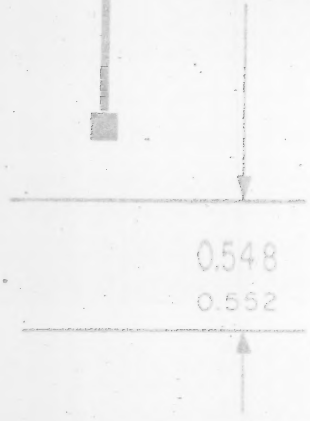


BASIC definitions necessary for the study of dimensions and tolerances are outlined in the first two articles in this series. Part 1 has discussed the meanings of precision and accuracy. The present article defines two equally important concepts: (1) tolerance zones for points, lines and surfaces, (2) relationships between different types of dimensions and tolerances.

Tolerance Zones

Mechanical parts are described by points, lines and surfaces in space. The concepts involved are extensions of similar concepts developed in Part 1 for single dimensions. Although a discussion of these properties may seem rather academic, it is nevertheless fundamental to the understanding of complex dimension relationships.

Points on a Plane: An ideal dimension can be said to be dimension without tolerance. No matter what kind of a co-ordinate system is used, ideal dimensions locate points equally well, *Fig.* 7.

In *Fig.* 8, a point located by means of limits can fall anywhere on the frame defined by the intersecting limits. The frame, shown by the heavy lines, represents the tolerance zone for the point. Note that the shape of the tolerance zone depends on the choice of co-ordinate system.

For dimensions with rectangular distributions, *Fig.* 9, the tolerance zones are areas; a point can fall anywhere in a cross-hatched area. Here again, shape of the tolerance zone depends on the co-ordinate system involved.

When the two dimensions that locate a point are normally distributed with equal—or equivalent—tolerances, then for all practical purposes the tolerance zone is a circular area ($t \approx t_a \approx t_b$; $t \approx t_r \approx \bar{x}_r t_\gamma$). Therefore, shape of the tolerance zone is independent of the co-ordinate system, *Fig.* 10.

The reasoning behind the use of a circular tolerance zone is illustrated by *Fig.* 11. The point is located by two dimensions, each described by a normal distribution. If the tolerances are approximately equal, the circle shown in the figure is a line of equal probability. The probability that a dimension will fall within a circle of $2u_\sigma$ diameter is given in *Fig.* 11. Thus, if $t = 8_\sigma$ the chance of a point falling inside a circle of 8_σ diameter is theoretically better than 99.95 per cent.

Although the justification for a circular tolerance zone has been shown only for rectangular co-ordinates, it is fairly evident that the tolerance zone for polar co-ordinates will be practically circular if t_r is approximately equal to $\bar{x}_r t_\gamma$, assuming that the dimensions are normally distributed.

Lines on a Plane: Tolerance zones for lines on

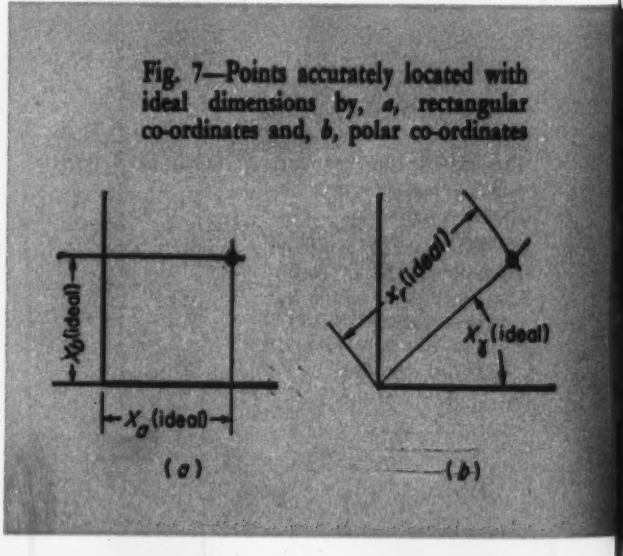


Fig. 7—Points accurately located with ideal dimensions by, *a*, rectangular co-ordinates and, *b*, polar co-ordinates

IN DESIGN

A systematic study of methods for controlling effects of tolerances and design geometry

Part 2—Tolerance Zones; Related Dimensions

a plane are illustrated by *Fig.* 12 for both dimension limits and rectangularly distributed dimensions.

Tolerance zones for limits are the envelopes of tolerance zones for points on the line. For straight lines and arcs of circles defined by one dimension, the tolerance zones are coincident with the limits, although this is not so for irregular lines.

When dimensions are rectangularly distributed, tolerance zones are the areas between the envelopes. The dotted lines in *Fig.* 12 show what a rectangularly distributed line may look like.

Tolerance zones defined by normal distributions are illustrated by *Fig.* 13. Note that the tolerance zones for irregular lines have constant width. Lines defined by normally distributed dimensions will tend to be closer to the mean than lines defined by rectangularly distributed dimensions.

Although many dimension problems can be treated as plane problems—for instance, when parts are relatively thin and flat—the general dimension problem is a problem in space. Everything said so far concerning tolerance zones for points and lines on a plane has a corollary in three-dimensional space.

Tolerance Zones in Space: Two co-ordinate systems, rectangular and polar, are commonly used for locating points on a plane, but three are used for locating points in space: rectangular, cylindrical, and spherical, *Fig.* 14.

When the locating dimensions are defined by limits, the tolerance zones are the boundary surfaces. The volume within the boundary surfaces is the tolerance zone when the dimensions have rectangular distributions. For normally distributed dimensions, the tolerance zone is a volume in a sphere, *Fig.* 14*d*—assuming, of course, that the tolerances of the three co-ordinate dimensions are approximately equivalent.

Tolerance zones for lines and surfaces in space can be defined by the envelopes of the tolerance zones of points in space, *Fig.* 15. Thus, *Figs.* 15*a* and *b*, the tolerance zone for dimensions defined

Fig. 8—Tolerance zones for points on a plane located by limits. The zones are indicated by the heavy lines; shape of the zone depends on the co-ordinate system

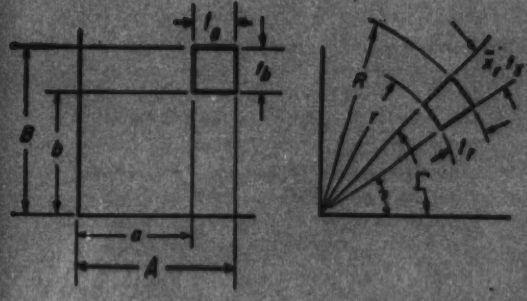
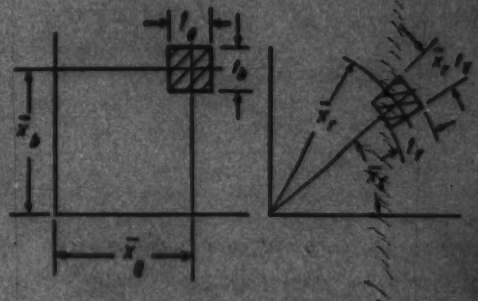


Fig. 9—Tolerance zones for points located by rectangularly distributed dimensions. By contrast with *Fig.* 9, the zones are the cross-hatched areas



by limits are the boundary surfaces; for rectangularly distributed dimensions the tolerance zones are the volumes enclosed by the boundary surfaces. When dimensions are normally distributed, the tolerance zones for lines and surfaces in space have constant thickness, *Figs.* 15*c* and *d*.

Choice of a co-ordinate system depends on whether the part can be described effectively by the particular dimension or combination of dimensions. It also depends on whether the dimensions are compatible to manufacturing and inspection practices. It should not be inferred, of course, that only one co-ordinate system should be used in describing a particular part; a combination of dimensions using two or even three co-ordinate systems is more the rule than the exception.

Nomenclature

$A, B, \ldots$ = Upper (maximum) tolerance limits for the dimension $x_a, x_b, \ldots$

$a, b, \ldots$ = Lower (minimum) tolerance limits for the dimension $x_a, x_b, \ldots$

P = Probability that a dimension or dimension condition will occur within specified limits

R, r = Upper and lower tolerance limits respectively, for the radial dimension x_r

t = Tolerance, equal to the maximum tolerance limit minus the minimum tolerance limit

u = Standardized normal variable (standard deviation of a standardized normal distribution)

v = Variation of a dimension condition, a tolerance equal to the absolute value of the difference between limits of a dimension condition; effectively, the sum of the two dimension tolerances defining the dimension condition

x = Dimension (a variable)

$\bar{x}$ = Mean (arithmetic average) dimension

y = Dimension condition, a dimension which results from combining two other dimensions

Γ, γ = Upper and lower tolerance limits, respectively, for the angular dimension x_γ

σ = Standard deviation of a probability distribution

Subscripts

$a, b, \ldots$ = Individual length dimension or tolerance; defined by $A, a; B, b, \ldots$ for limit dimensions

r = Individual radial length dimension or tolerance; defined by R, r for limit dimensions

γ = Individual angular dimension or tolerance; defined by Γ, γ for limit dimensions

1, 2, . . . = Individual values for dimensions or tolerances

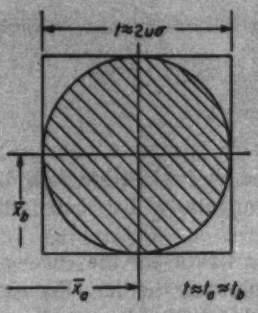


Fig. 11 — Details of the circular tolerance zone of *Fig.* 10. Table shows the probability, P, of a point located by two normally distributed dimensions falling within the tolerance zone

P	0.5	0.7	0.9	0.99	0.999	0.9995
u	1.18	1.55	2.14	3.04	3.72	3.90

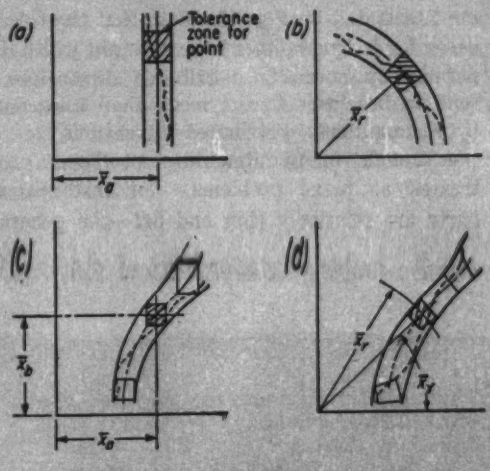


Fig. 12—Tolerance zones for lines on a plane as defined by points located by limits and by rectangularly distributed dimensions. For rectangularly distributed dimensions, the tolerance zones are the areas defined by tolerance zones for points on the lines; for limit dimensions, they are the boundary lines of these areas. Notice that a change from rectangular to polar co-ordinate dimensioning in *c* and *d* produces a change in shape of the tolerance zone

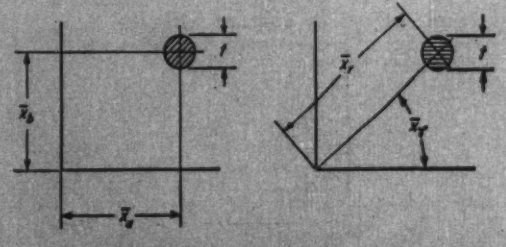


Fig. 10—Circular tolerance zones for points located by normally distributed dimensions. Assumption is that tolerances for each of the two dimensions are approximately equal

Related Dimensions

An ideal mechanical part—a part as it is first conceived by the designer — must eventually be thought of as consisting of functional and nonfunctional surfaces. The relationships of functional surfaces are extremely important. The dimensions that control these relationships, and the relationships themselves, define the complex geometrical characteristics of mechanical parts.

Functional and Nonfunctional Surfaces: The mating surfaces indicated by the heavy lines in *Fig.* 16 are examples of functional surfaces. In general, all mating surfaces are functional, but of course not all functional surfaces are mating surfaces. Relationships between functional surfaces are controlled by *functional* dimensions, and between nonfunctional surfaces by *constructional* dimensions. In addition to these relationships, there are relationships between functional and nonfunctional surfaces. The dimensions that control these relationships may, for want of a better term, be called *connecting* dimensions.

Relationships of Functional Surfaces: In the theoretical discussion about points, lines, and surfaces, tolerance zones were defined by dimensions located from hypothetical planes. The counterparts of these hypothetical planes, when considering real mechanical parts, are the base planes. In *Fig.* 16 surface *A* is the base plane from which

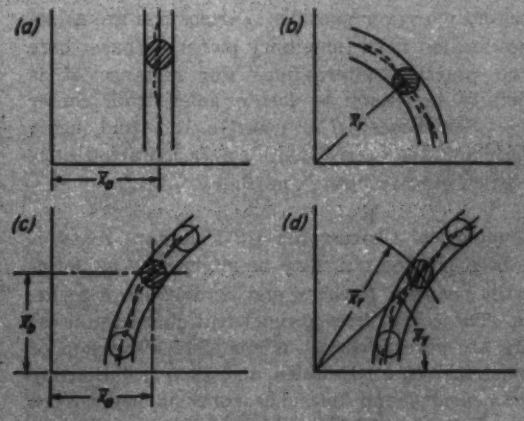


Fig. 13—Tolerance zones for lines when dimensions are normally distributed; the zones are areas defined by tolerance zones for individual points

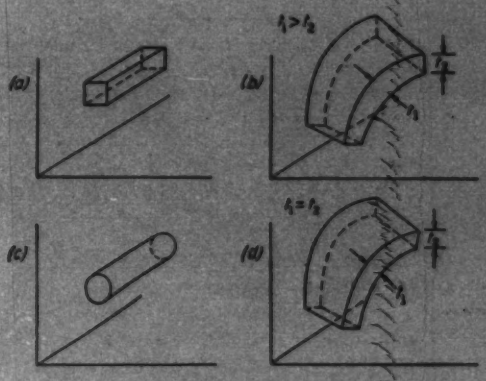


Fig. 15—Tolerance zones for lines and surfaces in space: *a* and *b*, limit and rectangularly distributed dimensions; *c* and *d*, normally distributed dimensions

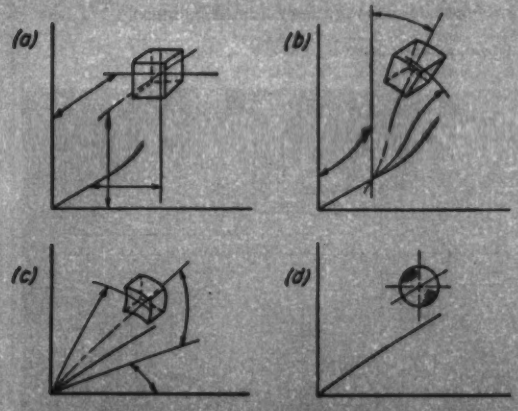


Fig. 14—Three-dimensional tolerance zones for points in space. Zones are for dimensions defined by limits or by rectangular distributions using: *a*, rectangular co-ordinates; *b*, cylindrical co-ordinates; and *c*, spherical co-ordinates. For normally distributed dimensions, *d*, the tolerance zone will be a sphere (tolerances approximately equal) regardless of the co-ordinate system

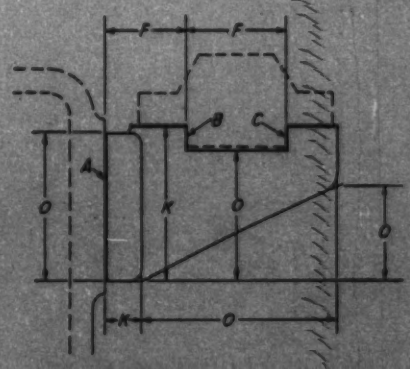


Fig. 16—Different types of dimensions: *F*, functional; *O*, constructional; and *K*, connecting

surface B is located, and surface B is the base plane from which surface C is located.

The question might be asked: Why not call surface C a base plane to start with, and reverse the order in which the surfaces are located? In many cases the actual order is quite arbitrary, but when a part has both functional and nonfunctional surfaces, the connecting dimensions pretty well establish what surfaces must be machined first. Location of the connecting dimensions should, therefore, be chosen with regard to manufacturing, tooling and inspection practices.

Relationship between surfaces B and C in *Fig.* 16 is important because it controls the fit with the tongue of the mating part. One interpretation of the tolerance zone for surface C is shown in *Fig.* 17*a*. This interpretation assumes that surface B, the base plane, is flat and parallel with surface A. The other interpretation, shown by *Fig.* 17*b*, is a modification of the ideal tolerance zone and base plane relationship; both surfaces may be other than flat and parallel as long as each surface is within its tolerance zone.

Dimensioning surface C with respect to B in *Fig.* 16 is an example of observing the rule: Wherever possible control the relationship of two functionally dependent surfaces with a single dimension. This rule has been violated in *Fig.* 18; not one, but two dimensions control the width of the groove. The measurement across the groove, y, is no longer a dimension but is a *dimension condition*. The *variation* of the dimension condition, v, is the sum of the two dimension tolerances.

The base planes shown in *Fig.* 16 are real surfaces; this is good practice and should be observed wherever possible. Dimensions are sometimes located from imaginary planes because there is no practical alternative. For instance, it is generally necessary to locate holes from center lines. Sometimes it is possible to avoid using imaginary base planes merely by a more judicious choice of dimensions, *Fig.* 19.

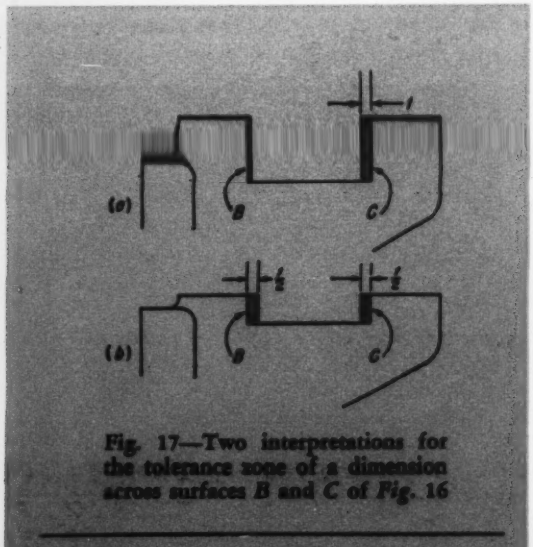


Fig. 17—Two interpretations for the tolerance zone of a dimension across surfaces B and C of *Fig.* 16

Geometrical Characteristics: Tolerance zones, it has been pointed out, may be interpreted as defining the *position, flatness,* and *parallelism* of a surface. These are three geometrical characteristics; there are several more. A complete discussion of geometrical characteristics and their relationship to dimensions and tolerance zones is beyond the scope of this article; further information is available.[2,3] However, a list of geometrical characteristics separated into three categories might be:

Feature . . . Profile . . . Straightness . . . Squareness . . . Roundness . . . Flatness . . . Parallelism

Location . . . Position . . . Symmetry . . . Concentricity . . . Alignment

Surface . . . Roughness . . . Waviness . . . Lay

[2]References are tabulated at end of article.

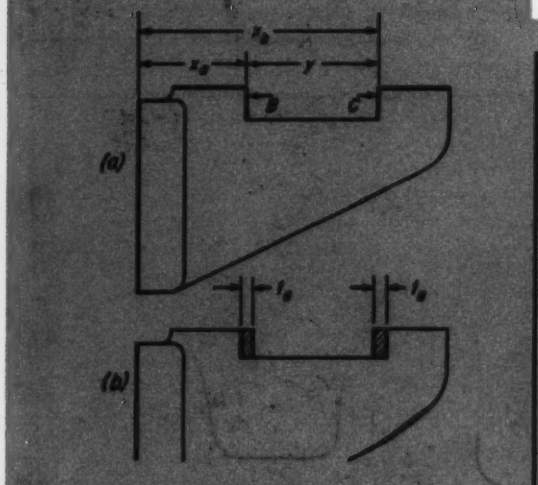


Fig. 18—An indirect dimensional relationship, y, between surfaces, *a*. At *b* are the corresponding tolerance zones

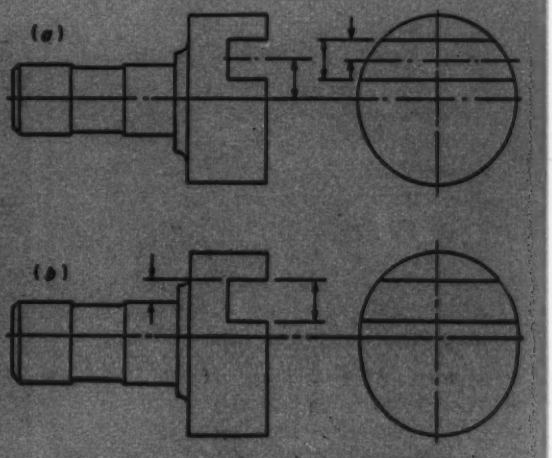


Fig. 19—Examples of dimensioning practice using, *a*, imaginary datums or base planes, and *b*, real surfaces

A common-sense attitude should be adopted about specifying tolerances for geometrical characteristics other than ordinary length and angle dimensions. If sufficient care is not observed, some of these characteristics may absorb all of the tolerance zone, and difficulties in manufacture, inspection or operation may be encountered.

Often a particular characteristic is especially important for functional reasons—for example, the flatness of a face seal, the straightness of a lathe bed, and the roundness of a journal. But where these geometrical characteristics are not particularly important, and where the tolerance zones are large enough to allow for normal manufacturing practice, then special geometric tolerances may be unnecessary to specify.

Future Articles: The next two parts of this series will discuss limit dimensions. In particular, they will show how to analyze mechanical assemblies and how to locate sources of variation in individual mechanisms and design geometry. Later articles parallel these discussions for probability principles and point out practical applications.

REFERENCES

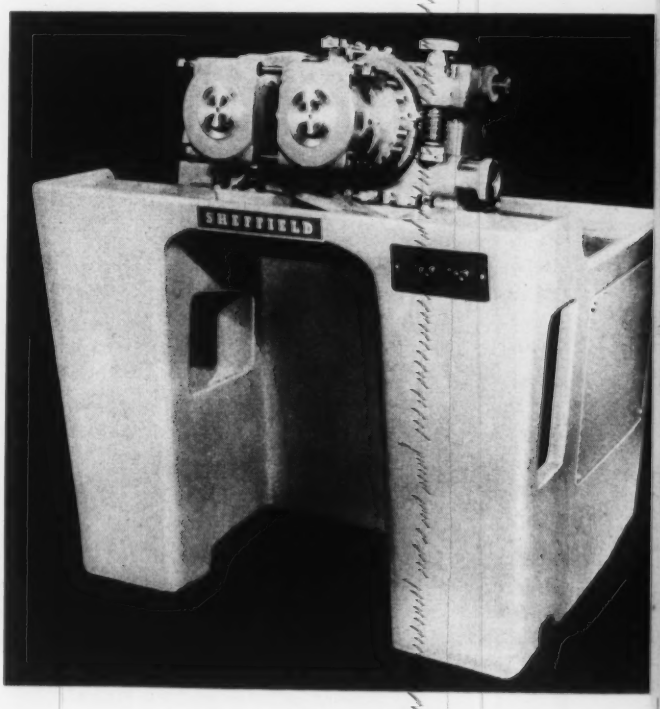
2. *Dimensiona. Analysis of Engineering Designs, Vol. 1—Components,* Ministry of Supply, HMSO, London, England, 1948. (Contains excellent discussions of tolerance zones and relationship of tolerance zones to geometrical characteristics.)
3. W. Abbott—*The Dimensioning of Engineering Drawings,* Blackie and Sons, London, England, 1953. (See comment on Reference 2).

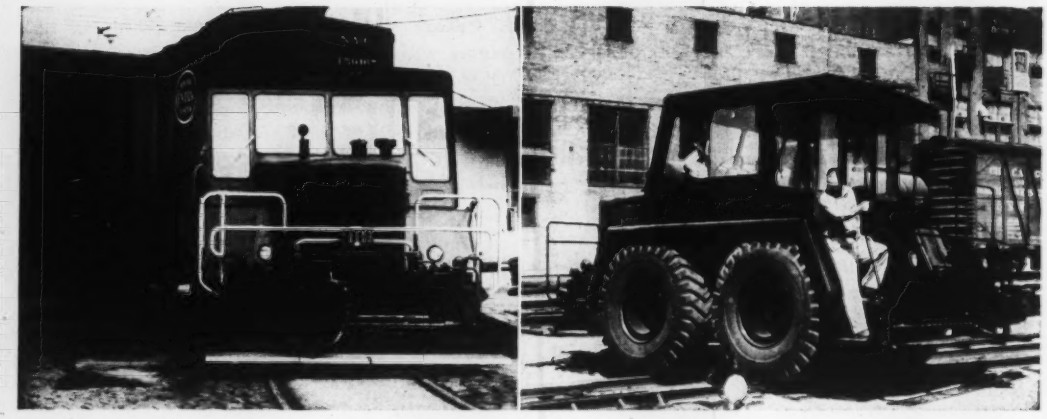
Contemporary Design

Thread Roller Has Modern, Functional Styling

SMOOTH, functional styling of a recently-introduced thread rolling machine more nearly resembles that of a piece of modern furniture than a machine tool. The desk-like base has knee room for the machine operator and measures 3 by 4 ft. Functionally, the base serves as a housing for the 7½-hp drive motor, coolant tank and coolant circulating pump.

Produced by Sheffield Corp., the machine will roll threads of any form on as many as 5200 pieces per hour within the size ranges of zero to ¼-in. OD by 2 in. long, 5/16 to 7/16-in. OD by 1½ in. long, and ½ to 9/16-in. OD by 1¼ in. long. Parts are fed tangentially between the forming rolls by a revolving work feeder ring. The feeder ring can be magazine loaded, manually or automatically.





Rubber-Tired Switch Engine Needs No Rails

CHARACTERISTICS of a switch engine and a large earthmoving vehicle are combined in the Switchmobile built for the Pennsylvania Railroad by LeTourneau-Westinghouse Co. Unlike other vehicles for rail and road travel, the Switchmobile has no system by which it can actually travel on the rails. The tread or distance between its large tires is great enough to allow it to straddle the rails and simply roll along on the ties. Pressure in the 18:00 x 25 tires is low enough to prevent damage to the ties and also permits the vehicle to travel across tracks without damage to rails, switches or signal equipment. Travel on roads or city streets to the place where the Switchmobile's services are required is also possible.

Styling of the Switchmobile is unquestionably railroad. Hand rails, steps, foot boards, couplers and air hoses are identical with those on conventional switch engines. The cab furthers the impression of a locomotive. It is stand-up height and standard locomotive width. Large windows all around provide 360-degree visibility with no blind spots for the operator.

Controls are mounted on an arm which swings from a pedestal in the cab so the operator can tilt steering wheel, instrument panel and other controls into position for traveling in either direction. Two seats are also installed to permit the operator to face in either direction of travel. To take full advantage of this ambidirectional feature, the transmission provides the same four speeds for either direction of travel.

Other components of the power train are a 208-hp diesel engine and a torque converter. All four wheels of the vehicle are driven to produce maximum tractive effort of 30,000 lb. This is sufficient to move a gross weight of more than 1000 tons from a standing start.

Contemporary Design

How to

REDUCE NOISE IN SHEET-METAL ENCLOSURES WITH FLEXURAL DAMPING MATERIALS

By T. Mariner and F. G. Dochat
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SHEET metal is an ideal material form for many applications. Among its many advantages are strength, wear resistance, dimensional stability, and the precision and speed with which mass-produced shapes may be turned out. One disadvantage of sheet metal, however, is its "noise" characteristics. It is slow to dissipate any vibrational motion imparted to it because of its small internal friction or mechanical hysteresis. If a bare sheet-metal panel is caused to vibrate by an impact or mechanical shock, the vibrations continue for a considerable time. Or, if vibrational energy is continuously supplied to the panel, as in the case of a motor shaking an appliance, the magnitude of the panel vibrations may become quite large. The large amplitude of motion and the prolonged time of vibration both contribute to noisiness.

Role of Damping Materials: Fortunately, materials having the ability to decrease the magnitude and duration of vibrations may be added to sheet metal quite inexpensively. There are many types of these so-called vibration damping materials, of which asphalt saturated sheathing felt paper is one of the most widely used. Sheathing felt paper falls in the class of flexural vibration damping materials, so named because, as thin layers of semirigid material adhered uniformly to the vibrating panel, they are caused to undergo bending or flexure as the panel bends in the course of its vibrations.

Effectiveness of a vibration-damping material in a particular application depends not only on specific properties of the material, but also on the elasticity, size, shape, and constraints of the panel to which it is applied. In principle it is possible to measure the stiffness and self-damping of the panel, as well as pertinent geometry, and then to calculate what properties a vibration damping material must have in order to produce the desired results. In practice, however, this approach is seldom used. In most cases the equations are insoluble by ordinary methods, and in all except a few purely academic cases the mere formulation of the problem and the measurement of the properties of the bare sheet metal panel take more time than a simple empirical approach.

It is therefore customary in engineering the vibration damping of a particular sheet-metal panel to select a material on the basis of intuition or previous experience, apply it to the panel, and observe whether it adequately inhibits vibration and noise. Depending on whether or not the first trial is satisfactory, another material may be selected with a known effectiveness differing from that of the original material by a factor of two in the appropriate direction. Two or three trials usually are sufficient for final selection of a material which balances appropriately the objectives of economy and noise reduction.

Evaluation of Damping Materials: Use of the empirical approach, of course, requires prior knowledge of the relative effectiveness of a series of suitable materials covering a wide range of vibration damping efficiencies, which in turn implies a method of measuring the relative vibration damping efficiencies. Such a method was devised by the late Dr. P. H. Geiger of the University of Michigan, (*Noise Reduction Manual,* University of Michigan Press).

In this method, now commonly called the "thick-plate" method, the vibration damping materials are rated according to their ability to damp the vibrations of a steel plate 20 inches square and ¼-

inch thick, supported near the centers of the four edges on the nodal line, or line of essentially zero motion for the fundamental vibration of the plate, which has a natural frequency of about 160 cycles per second. This frequency has been selected since it lies near the center of the low frequencies which are not only loudest but most difficult to eliminate in automobile bodies and many other sheet-metal structures involving large panels.

In a preferred variation of Geiger's method the bare-plate damping, consisting of the self-damping of the plate and the damping due to the supports of the test equipment, is determined first. The slope of the vibration decay curve, traced on a logarithmic scale, is measured for a bare plate on the supports. Then a sample of damping material is applied to the plate and a similar test is made. In order to determine the effect of the damping material alone, the previously determined bare plate damping is subtracted from the gross damping rate of the second test. In this way the net damping efficiency of any damping material is determined and expressed in decibels per second.

Absolute values of damping rates thus obtained strictly apply only to a 20-inch square, ¼-inch thick cold-rolled steel plate at a frequency of about 160 cps. In practical applications the absolute damping rates will generally be greater because the more commonplace sheet-metal panels are not as stiff as the test plate. But, for flexural materials the relative magnitudes of damping rates are preserved to a surprising degree in different mechanical arrangements involving plates of different sizes, shapes, and thicknesses. Therefore, the figures obtained in this simple test are usually adequate for applying the empirical procedure when flexural damping materials are used.

Damping rates of most flexural materials have a minor dependence on frequency, being generally higher at higher frequencies. The performance of some other types of damping materials is quite frequency-dependent, and these materials require more consideration before the thick-plate test values are used as a basis for general engineering. However, only flexural damping materials, such as sheathing felt papers, are discussed here.

Fractional Plate Coverage: A specified small area of flexural damping material is most effective when placed at an antinode of the vibrational pattern of the panel to be damped. For the usual regular shapes, such as square or circular panels, the antinode for the fundamental frequency is at the center of the panel. Thus, it is often more economical to use a small patch of more expensive and more effective damping material near the center of a panel than to cover the entire panel with a less expensive and less effective material. Or, if a definite quantity of a particular material is to be used, it will often give greater damping when employed in double thickness over half the area, rather than when employed in a large patch of single thickness.

In any application of this idea to obtain greater economy, it is important not to get the patch too small. Occasionally, the higher frequency modes of vibration may be as important as the fundamental in mechanically driven equipment. Although the higher frequencies are inherently more easily damped, the fact that they have more antinodes than the fundamental means that the effectiveness of a particular type of damping material will be more nearly proportional to the area of the plate covered. In general, for regularly shaped panels, it is desirable to cover no less than ¼ of the total panel area near the center, although in some cases a smaller area may work satisfactorily.

The economic implications of the reduced-area technique are of interest. Because of the precision with which results can be duplicated, the fundamental vibration of the free-edge plate is selected here as an example. Damping rates due to the damping material alone have been determined for various fractions of total plate area covered at the center of the standard test plate. The results are given in *Fig.* 1, which will serve as the basis for most of the following discussion. Another useful fact is that doubling the thickness of a thin

Table 1—Relative Damping Characteristics
Based on Type 1 Felt

Felt Type No.	Relative Thick-Plate Damping Rate	Required Fraction of Full-Plate Damping	Required Fraction of Full-Plate Coverage	Relative Cost Per Unit Area	Relative Cost for Equivalent Damping of Fundamental
1	1.0	1.0	1.0	1.00	1.00
2	1.4	0.71	0.49	1.20	0.59
3	1.3	0.77	0.47	3.01	1.41
4	2.5	0.40	(0.19) 0.25	1.39	(0.26) 0.35
5	3.2	0.31	(0.14) 0.25	1.81	(0.25) 0.45
6	4.1	0.24	(0.10) 0.25	3.18	(0.32) 0.80
7	1.9	0.53	0.29	1.44	0.42
8	2.1	0.48	0.25	1.86	0.47
9	2.6	0.38	(0.18) 0.25	3.29	(0.59) 0.82
10	7.1	0.14	(0.05) 0.25	2.82	(0.14) 0.71
11	3.3	0.32	(0.14) 0.25	3.18	(0.45) 0.80
12	5.2	0.19	(0.07) 0.25	5.15	(0.36) 1.29

flexural damping material increases the basic damping rate by a factor of three. What these data mean can be best demonstrated by several examples.

Example 1: Suppose a sheathing felt paper is selected of such characteristics that it gives the desired damping rate with full plate coverage. Assume that this is a sheet 0.1-inch thick, costing about $0.20 per sq yd. In double thickness, it would cost about $0.40 per sq yd for material, $0.06 per sq yd for laminating, or a total cost of $0.46 per sq yd.

The laminated felt, having three times the basic damping rate of a single thickness, need yield only 1/3 of the full-coverage damping in order to give the same performance as a single ply over the whole plate. *Fig.* 1 shows that this result can be accomplished with a central patch covering 15 per cent of the plate area. A simple calculation shows that use of the laminated felt saves 65 per cent of the cost of the single-ply felt and 85 per cent of the cost of adhesive for applying the felt. Savings of this order of magnitude may not always be realized in a practical case if the conditions favor excitation of overtones rather than the fundamental vibration. Moreover, it may not always be possible to get factory-laminated felts so economically in small quantities.

Example 2: Potential savings of partial panel coverage can be analyzed in relation to the series of standard felts listed in *Table* 1. The table is based on the assumption that the empirical method for selection of a damping material has led to the conclusion that a full panel treatment with type 1 felt is satisfactory. Then, from the relative damping rates for the other types of felt, the required fraction of full-panel damping has been calculated for each of the felts.

From these values and *Fig.* 1 the fraction of plate area requiring treatment has been calculated as shown in column 4. Multiplying column 4 by the relative price of the felts per unit area given in column 5 yields the relative cost of equivalent damping treatments listed in column 6. In keeping with the rule of thumb that at least ¼ of the plate must be covered, columns 4 and 6 list two figures for types of felt for which straight-forward calculation indicates that less than 25 per cent of plate area need be covered. The figures in parentheses show the cost associated with calculated fractional areas less than 25 per cent.

Column 6 shows that type 4 felt covering 25 per cent of the plate area at the center gives 54 per cent of the damping rate obtained with full plate coverage. Use of a patch of type 4 felt gives 35 per cent more damping than full coverage with type 1 felt.

Example 3: Suppose that the empirical selection technique has led to the conclusion that full plate coverage using type 4 felt is appropriate from the point of view of vibration damping. Study of other felts which can supply at least this much damping shows from *Table* 2 that type 10 felt is most economical, even under the limitation that at least 25 per cent of the plate area must be covered. Moreover, this selection gives 51 per cent more damping

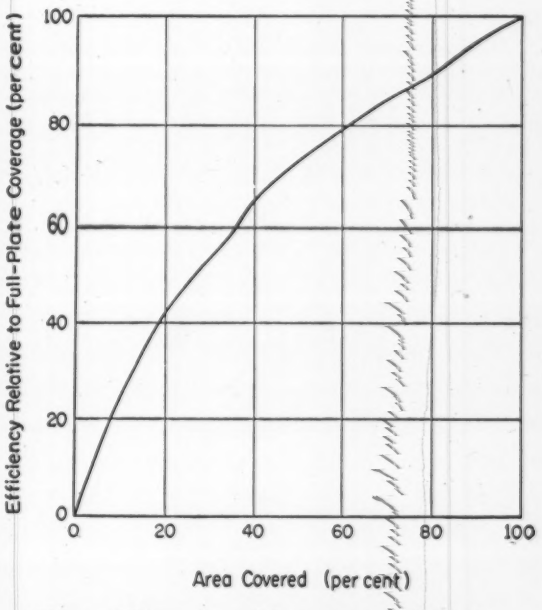

Fig. 1—Effect of partial coverage. Felt patch must be located at center of plate or panel

Table 2—Relative Damping Characteristics

Based on Type 4 Felt

Felt Type No.	Relative Thick-Plate Damping Rate	Required Fraction of Full-Plate Damping	Required Fraction of Full-Plate Coverage	Relative Cost Per Unit Area	Relative Cost for Equivalent Damping of Fundamental
4	1.0	1.0	1.0	1.00	1.00
5	1.3	0.77	0.57	1.30	0.74
6	1.6	0.62	0.37	2.29	0.85
9	1.0	1.0	1.0	2.37	2.37
10	2.8	0.36	(0.16) 0.25	2.03	(0.32) 0.51
11	1.3	0.77	0.57	2.29	1.30
12	2.1	0.48	0.25	3.70	0.92

than type 4 felt applied over the whole plate.

Summary: Qualitative relationships displayed in *Fig.* 1 and in *Tables* 1 and 2 refer to the fundamental vibration of a free-edge square plate. Similar qualitative relationships apply to all flat plates of simple shape. To a first approximation, the data of *Fig.* 1 may be used as a basis for selecting from a series of otherwise suitable felts the most promising candidates for experimental central patch treatment.

A recommended procedure in a practical case is first to determine how efficient a damping material is required to give satisfactory results when applied over the whole panel. This may be done using the empirical approach described early in the discussion. Then, from manufacturer's data on prices and relative efficiencies of a number of otherwise appropriate felts, *Fig.* 1 may be used to determine approximately equivalent damping treatments for all the felts, as well as the relative cost of these treatments.

The indicated most economical central patch treatment may then be tried to see if it gives results equivalent to full panel treatment, with the felt of lower efficiency first selected. If it works, all is well. If not, the chances are that high overtones are more important than the fundamental in the particular case in question and full panel coverage should be used. While patch treatment may be used successfully and with some economy in damping overtones of flat panels of simple shape as well as the complex vibrations of irregular and nonplanar panels, the work involved in determining the proper location and size of patches seldom is justified by the savings if it is found that central patch treatment is unsuccessful.

The procedure outlined in this discussion is so simply applied and so frequently successful that it should be considered routinely whenever vibration damping is being engineered for mass-produced products involving sheet-metal panels. The patch treatment, of course, is not to be considered when the sheathing felt serves other purposes in addition to vibration damping, such as thermal insulation, which may require full panel coverage.

Contemporary Design

Printed Circuits Reduce Dictating Machine Size

DESIGNED primarily for the traveling business man, a recently introduced dictating machine makes full use of printed circuits to achieve small size. Measuring 10 in. long, 6¼ in. wide and 2⅞ in. high, the unit will fit into a briefcase or automobile glove compartment. A snap - on shoulder strap is also provided to permit carrying it over the shoulder. Called the Soundscriber 200, the machine is claimed to be the smallest and lightest of its type in the world by its manufacturer, the Soundscriber Corp. The aluminum housing is available in a number of solid or contrasting colors.

Dictation is recorded on 3-in. diameter disks holding 8 minutes of dictation or 3⅞-in. diameter disks with 15-minute capacity. Starting and stopping are controlled by a push-button integral with the small microphone which also serves as a speaker for playback. A volume control is provided to vary the sound output level. Separate arms are used for recording and playback.

How to predict effects of

UNDERCUTTING

Hobbed Spur Gear Teeth

By M. F. Spotts
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SUCCESSFUL designing of a pair of gears involves geometrical requirements necessary to secure smooth and continuous action. Importance of correct geometry increases as the number of teeth in a gear is reduced. The duration of contact must be long enough to provide an overlap between successive pairs of mating teeth. In particular, any undercutting of the teeth must not reduce the length of contact below a satisfactory minimum value.

A normal pair of involute gears with pressure angle ϕ is illustrated in *Fig.* 1. All gear action between the teeth takes place along the pressure line AB which is tangent to the two base circles. The length of contact l_c is limited to the segment A_1B_1 determined by the points where the two addendum circles cross the pressure line. The distance from one tooth to the next, measured along the pressure line, is known as the normal or base pitch p_b. As illustrated by *Fig.* 2, p_b can be found by dividing the circumference of the base circle by the number of teeth in the gear.

The number of tooth intervals in l_c, or contact ratio, is found by dividing l_c by normal pitch p_b. To secure smooth operation l_c should be greater than p_b, allowing a new pair of teeth to come into engagement before the pair that has been carrying the load separates. A recommended minimum value for contact ratio is 1.4.[1] Successful operation under favorable conditions has been secured at smaller values—even for a contact ratio as low as 1. This can probably be explained by the fact that under load the elastic deformation of the teeth gives a considerable increase in the duration of contact.[2]

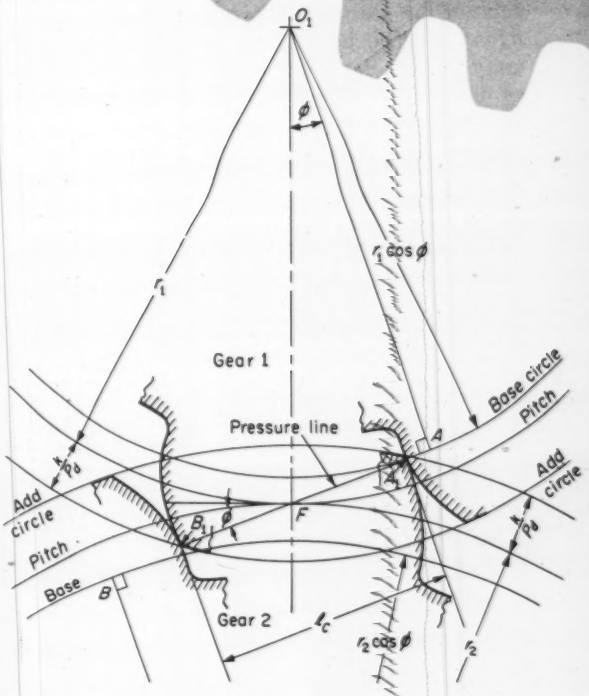


Fig. 1—Length of contact traversed by teeth of mating gears

When the number of teeth in a gear becomes small, the ideal conditions of *Fig.* 1 no longer prevail. Length AB may become shorter than A_1B_1 so that the addendum circles for one or both gears intersect projected pressure line beyond interference points A and B. Such gears would be "undercut" during manufacture. A great advantage of a generating process such as hobbing or rack generation is that a single cutting tool can be used to

1. References are tabulated at end of article.

cut gears of all numbers of teeth. However, when the number of teeth is small, the tooth of the hob extends too deeply into the blank and produces undercutting, *Fig.* 3.

All gear action takes place on the involute, but the involute terminates at the base circle. The shaded portion of the cutter tooth in *Fig.* 3, extending inside interference point *A*, is thus unnecessary for satisfactory generation of the involute curve. In providing sufficient clearance for the tooth of the mating gear, the cutter has removed material lying outside the base circle and a portion of the involute curve is thereby lost. Loss of even a small amount of involute adjacent to the base circle is sufficient to shorten seriously the duration of contact between mating teeth. Another disadvantage resulting from the decrease of width of the tooth near the base is that the beam strength may be less than anticipated. The rule, as commonly stated, for determining whether or not a gear will be undercut, is to assume that if the working addendum k/P_d of the hob or rack cutter passes through or outside the interference point of the gear no undercutting will occur. Here P_d is diametral pitch and k is a constant such as unity for full-depth teeth, 0.8 for stub teeth, and so on. The rule thus assumes that the extension on the tip of the hob tooth necessary to give the clearance f has no effect on the undercutting. In *Fig.* 3 the radius of the base circle is $r \cos \phi$ and the vertical distance between A and the center of the gear is $r \cos^2 \phi$. According to the foregoing rule k/P_d must equal $r(1 - \cos^2 \phi)$ or $r \sin^2 \phi$. These quantities should be equated and P_d replaced by $N/2r$, where N is the number of teeth in the gear. Then

$$N = \frac{2k}{\sin^2 \phi} \qquad (1)$$

The minimum number of teeth that a gear may contain and yet be free from undercutting, as given by Equation 1, is:

For 14½-degree full-depth gears,	$k = 1$,	$N = 32$
For 20-degree full-depth gears,	$k = 1$,	$N = 17$
For 20-degree stub teeth,	$k = 0.8$,	$N = 14$

The problem at this point is the determination of length of contact for mating gears when some undercutting is present. If undercutting will reduce the length of contact below a suitable value, fundamental changes in design will be necessary. If undercutting is small, and the remaining length of contact is adequate, the presence of undercutting is usually immaterial.

General layout of an undercut gear is given in *Fig.* 4. The hob or rack tooth is straight-sided from G to K where the radius for clearance f starts. Extension f is omitted in the figure. Height of hob tooth above the pitch line is h, which is greater than the height of interference point A above the pitch line. Motions of the generating machine are such that arc FH around the pitch cirle of the blank is equal to FG along pitch line of the rack. In *Fig.* 4, the parts are in their terminal positions and any further motion to the right will cause the rack cutter and gear tooth to separate at K.

Undercutting has occurred and a section CK of the involute curve has been lost. Thus, point K determines the undercut circle which crosses the pressure line at D. Gear action is confined to interval FD instead of FA which would be available for undamaged teeth. A reduction in the value of h, or an increase in the pressure angle ϕ will reduce the amount of undercutting.

Nomenclature

f = Clearance extension on hob tooth, in.
h = Height of hob tooth above pitch line, in.
k = Tooth addendum constant
l_c = Length of contact, in.
m_u = Contact ratio, undercut to pitch point
N = Number of teeth in gear
P_d = Diametral pitch, teeth per in.
p = Circular pitch, in.
p_b = Normal or base pitch, in.
q = Undercut, measured radially, in.
r = Pitch radius, in.
ϕ = Pressure angle, radians

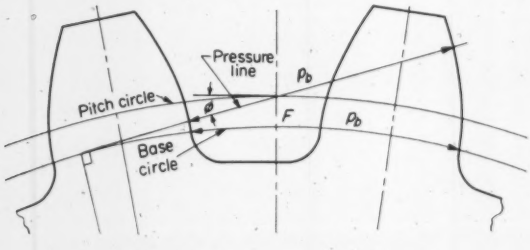


Fig. 2—Normal or base pitch, p_b, of involute gear teeth

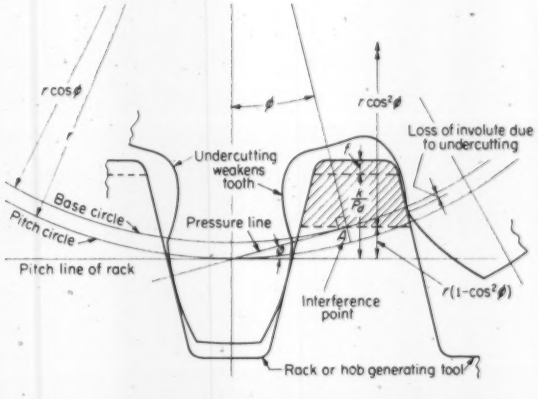


Fig. 3—Undercutting in gear having relatively few teeth

Shown in *Fig.* 5 is the generation of involute *JM* by the inextensible string *LM* as it unwinds from the base circle. From the figure,

$$\beta = \gamma - \alpha = \frac{\text{arc } JL}{r \cos \phi} - \alpha$$

Arc *JL* equals tangent *LM*, and the ratio $LM/r \cos \phi$ equals tan α.
Hence,

$$\beta = \tan \alpha - \alpha = \text{inv } \alpha \quad \ldots\ldots (2)$$

where it is customary to call angle β the involute function of α.

From *Fig.* 4 the following relationships are apparent:

$$\cos \alpha = \frac{r \cos \phi}{r \cos \phi + q} \quad \ldots\ldots (3)$$

$$\cos \psi = \frac{r - h}{r \cos \phi + q} \quad \ldots\ldots (4)$$

Undercut q is measured radially.

As previously mentioned, arc *FH* is equal to *FG*. This can be expressed in symbols from the figure as

$$FH = FG$$

$$r (\psi + \text{inv } \phi - \text{inv } \alpha) = (r - h) \tan \psi + h \tan \phi$$

Angle *COH* is the involute function of ϕ. The terms of the equation can be rearranged to give

$$r (\text{inv } \alpha + \text{inv } \psi) + h \tan \phi = h \tan \psi + r \text{ inv } \phi \quad \ldots\ldots (5)$$

Undercutting can be determined by Equations 3, 4 and 5, but in general the computations must be carried out by trial and error. For given values of r, ϕ, and h, Equations 3 and 4 are used to find α and ψ for a chosen value of q. Angles α and ψ thus determined must satisfy Equation 5, providing the correct value of q has been used.

Results of such computations for pressure angles of 14½ and 20 degrees are shown in *Tables* 1 and 2. Values shown are for a diametral pitch P_d equal to 1. Two forms of hob teeth are used for each pressure angle as shown in *Figs.* 6 and 7. The customary value for clearance f equal to 0.15708 is used.

For the rack cutter, designated as Type *A* in

Table 1—Undercutting and Contact Ratios for 14½-Degree Full-Depth Hobbed Spur Gears

		Type A Cutter		Type B Cutter	
N	r*	q*	m_a	q*	m_a
12	6	0.0656	0.206	0.0721	0.192
13	6.5	0.0579	0.254	0.0640	0.239
14	7	0.0509	0.303	0.0567	0.287
15	7.5	0.0445	0.353	0.0499	0.337
16	8	0.0387	0.404	0.0438	0.387
17	8.5	0.0334	0.456	0.0382	0.439
18	9	0.0286	0.509	0.0331	0.491
19	9.5	0.0243	0.562	0.0284	0.544
20	10	0.0204	0.616	0.0242	0.598
21	10.5	0.0168	0.672	0.0204	0.653
22	11	0.0137	0.728	0.0170	0.708
23	11.5	0.0110	0.784	0.0139	0.764
24	12	0.0085	0.841	0.0111	0.821
25	12.5	0.0064	0.899	0.0088	0.878
26	13	0.0047	0.958	0.0066	0.936
27	13.5	0.0032	1.016	0.0049	0.994
28	14	0.0020	1.076	0.0034	1.053
29	14.5	0.0011	1.136	0.0022	1.112
30	15	0.0005	1.195	0.0012	1.172
31	15.5	.....	....	0.0006	1.234

*Diametral pitch, P_d=1.

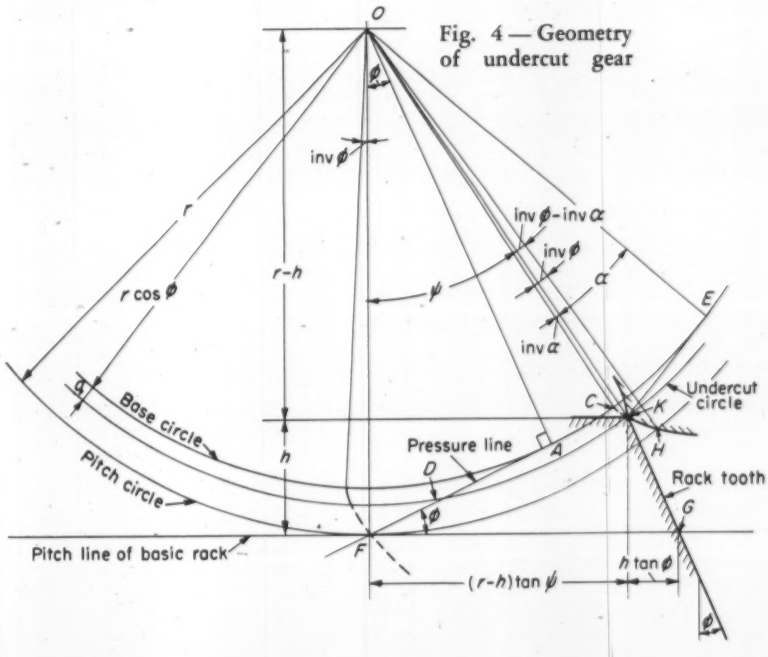


Fig. 4 — Geometry of undercut gear

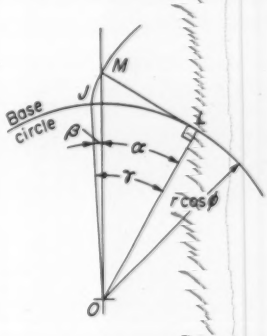


Fig. 5—Involute function of α, equal to β

Fig. 6, point of tangency K_a for the connecting arc is taken at the end of the standard addendum of the tooth. Dimensions for laying out the tip of the tooth are shown on the figure. For full-depth teeth and $P_d = 1$ the value of h is 1.

For the cutter designated as Type *B* in *Fig.* 7, the radius of the arc at tip of tooth is made equal to f. Point of tangency K_b is thus located outside the addendum within the clearance region. The value of h, for full depth teeth and $P_d = 1$, is $1 + f \sin \phi$.

As previously mentioned, distance from one tooth to the next measured along the pressure line is known as the normal pitch p_b. It is equal to the tooth-to-tooth measurement taken around the base circle. Hence,

$$p_b = \frac{2\pi r \cos \phi}{N}$$

where N is the number of teeth in the gear and r is the pitch radius. Since the circular pitch p of the teeth is equal to $2\pi r/N$, this equation can be written

$$p_b = p \cos \phi \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (6)$$

Table 2—Undercutting and Contact Ratios for 20-Degree Full-Depth Hobbed Spur Gears

		Type A Cutter		Type B Cutter	
N	r^*	q^*	m_u	q^*	m_u
10	5	0.0266	0.410	0.0326	0.391
11	5.5	0.0191	0.487	0.0243	0.467
12	6	0.0130	0.565	0.0174	0.545
13	6.5	0.0082	0.646	0.0119	0.624
14	7	0.0046	0.728	0.0074	0.705
15	7.5	0.0021	0.811	0.0041	0.787
16	8	0.0005	0.897	0.0018	0.871
17	8.5	.....	....	0.0004	0.956

*Diametral pitch, P_d=1.

The designer is interested in knowing the number of times the normal pitch is contained in length *FD* in *Fig.* 4. For $P_d = 1$, circular pitch $p = \pi$ inches. Then

$$DA = KE = r \cos \phi \tan \alpha$$

and

$$FD = FA - DA = r \sin \phi - r \cos \phi \tan \alpha$$

Hence, in *FD*,

$$m_u = \frac{r (\sin \phi - \cos \phi \tan \alpha)}{\pi \cos \phi}$$

$$= \frac{r}{\pi} (\tan \phi - \tan \alpha) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (7)$$

Values for the number of intervals are also given in *Tables* 1 and 2.

EXAMPLE 1: Two full-depth 14½-degree gears, 12 teeth each, are hobbed with Type *A* cutter. Find the available number of normal pitch lengths in the interval of contact if these gears are mounted to run together.

From *Table* 1, total number of normal pitch intervals is $2 \times 0.206 = 0.412$. This is much less than a single normal pitch and therefore is not satisfactory.

EXAMPLE 2: An 18-tooth 14½-degree full-depth involute gear is meshed with a 47-tooth gear. Gears are cut with Type *A* hob. Find the number of normal pitch intervals in the available length of contact.

18-tooth gear: By *Table* 1, length *FD* in *Fig.* 4 for this undercut gear contains 0.509 normal pitch intervals.

47-tooth gear: No undercutting is present, and reference should be made to *Fig.* 1. Solution will be found for $P_d = 1$. Results will be valid for all diametral pitches. For full-depth teeth, tooth

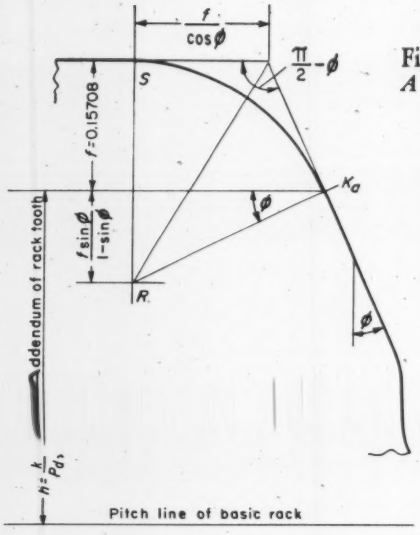
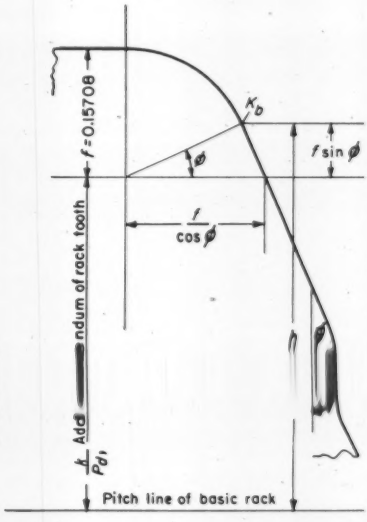


Fig. 6 — Type *A* hob tooth

Fig. 7 — Type *B* hob tooth



constant $k = 1$. Pitch radius is $r_1 = N_1/2P_d = 9$ in. To find distance B_1F,

$$O_1A = r_1 \cos \phi = 8.7133 \text{ in.}$$

$$B_1A = \sqrt{(O_1B_1)^2 - (O_1A)^2} = 4.9069 \text{ in.}$$

$$FA = r_1 \sin \phi = 2.2534 \text{ in.}$$

$$B_1F = B_1A - FA = 2.6535 \text{ in.}$$

Normal pitch, Equation 6, is

$$p_b = \pi \cos \phi = \pi\ (0.96815) = 3.0415 \text{ in.}$$

Number of normal pitches in B_1F is 2.6535/3.0415 = 0.872. Total number of normal pitches in length of contact is 0.509 + 0.872 = 1.381.

Although the smaller gear is undercut, the total "number of teeth in contact" would probably be satisfactory.

The tables indicate that the Type *B* cutter produces greater amounts of undercutting than Type *A*. The advantages of the 20-degree pressure angle, so far as undercutting is concerned, are obvious from the tables.

A seven-place table of natural trigonometric functions and a desk calculating machine were used in computing *Tables* 1 and 2. Certain values were checked graphically by means of large layouts to a scale of twenty times $P_d = 1$. Clearance f to this scale becomes π inches as indicated by *Fig.* 8. Templates for the involutes were constructed using the offsets given by Varnum.[3] Pitch and base circles were drawn and point *C* located at the angle $\psi - \text{inv}\,\alpha$ from the vertical. Involute *CH* can now be drawn. Point K_a is located by measuring radially from the base circle a distance equal to q or 20 × 0.0656 = 1.313 in. The outline of the hob tooth is then drawn as shown. The overlap between rack tooth and involute is indicated by shading.

Another point of intersection, say K_1, is found by shifting the cutter template along the horizontal, and shifting the involute template an equal amount along the pitch circle. The undercutting for this point is done by the straight portion of the addendum.

When the templates are shifted to the right, as for point K_2, the intersection takes place on the radius K_aS'' of the clearance f. The process can be continued until the locus $K_1K_aK_2$ of the point of intersection is obtained. Intersection ceases at some point high enough on the arc so that it has receded to the left sufficiently to prevent the cutter from making contact with the involute.

Value of q for point K_a at the corner of the addendum is not quite maximum value, as assumed by commonly used rules. The maximum occurs to the right of K_a where the intersection takes place on the arc. Here the lines cross each other very obliquely and it is difficult to locate accurately the point of maximum undercut. Very careful layout work indicates that the maximum value of q may be 1 to 2 per cent greater than that obtained for K_a at the corner of the addendum. It can therefore be concluded that no great amount of error is introduced by using the q values obtained for corner K_a as shown in *Figs.* 4 and 8 and listed in *Tables* 1 and 2.

When a Type *B* hob tooth is used for the gear in *Fig.* 8, the locus becomes $K_1K_aK_bK_3$. Here, too, the maximum is only a small percentage greater than that obtained by calculations for point K_b in *Fig.* 8 and recorded in *Table* 1.

When formations other than those of *Figs.* 6 and 7 are used at the tip of the cutter tooth, values different from those of *Tables* 1 and 2 for the undercutting will result. However, values of the table will aid in estimating the amount of undercutting to be obtained.

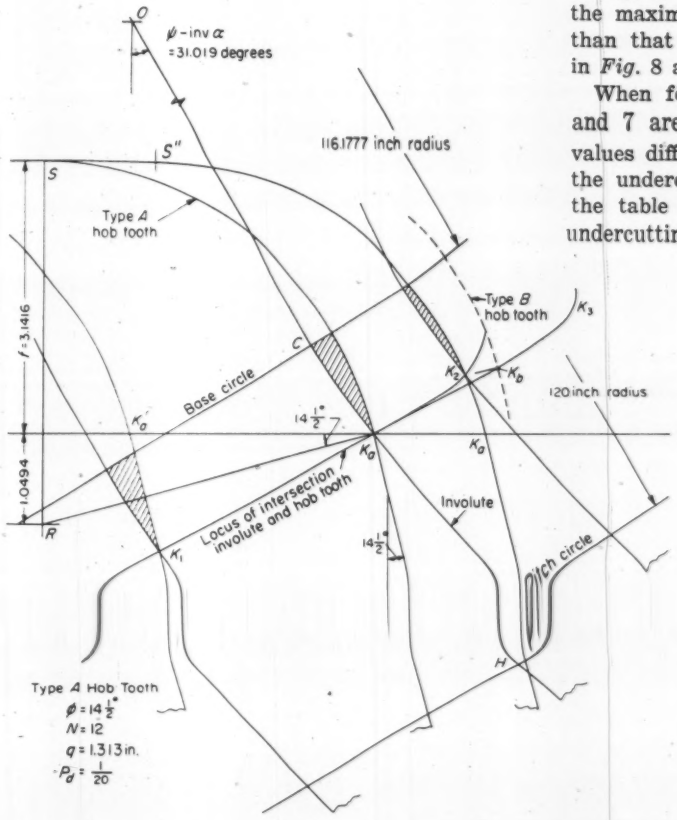


Fig. 8—Large-scale layout to illustrate extent of undercutting

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1. Buckingham—*Spur Gears*, McGraw-Hill Book Co. Inc., New York, 1928, Page 113.
2. Boor and Stitz—*Proceedings of the Society for Experimental Stress Analysis*, Vol 3. No. 2, 1946, Page 28.
3. Varnum—*Product Engineering*, Vol. 21. April, 1950, Page 102.

An outline of the characteristics and properties of

RUBBER

MATERIALS

Grade R

Natural Rubber: The most commonly used natural rubber for high-quality mechanical applications is smoked sheet or pale crepe when light colors are required. Among other grades are the European Estate thick brown crepes, European Estate thin brown crepes, remilled blanket, and thin brown crepes, and rolled brown crepe or flat bark crepe. The latter is considered the poorest grade since it is made of scraps from the barks of the trees and any scrap from the processing of other rubbers.

Natural rubber material exhibits the following properties or characteristics:

1. Resilience superior to synthetic rubber at normal temperature.
2. Low compression and permanent set.
3. Resistance to cold flow.
4. High tensile strength.
5. Good electrical insulation.
6. Good tear resistance.
7. Excellent abrasion resistance; however, GR-S is superior.
8. Better cold resistance than most synthetic rubber except special GR-S polymers.
9. Not as good as synthetic rubber for heat aging.
10. Not as good as some synthetics for resistance to sunlight, oxygen, or ozone. Special compounding, however, can give natural rubber good resistance to sunlight.

Basic Rubber Grades (ASTM Spec. D-735)

Grade	Other Designations		
R	Natural Reclaim	Buna S GR-S	Butyl BR-I
SC	Neoprene GR-M		
SB	Nitrile Buna N GR-N	Butaprene Hycar OR Chemigum	Paracril Perbuna GR-A
SA	Thiokol GR-P		
T	Silastic GE Silicone Gum		

GR-S or Buna S: The original, standard GR-S is a copolymer of butadiene (75 per cent) and styrene (25 per cent). A more recent development is called "cold rubber," since it is polymerized at 41 F instead of 120 F. Cold rubber has higher tensile strength and abrasion resistance than the regular GR-S material. GR-S rubber exhibits the following general properties and characteristics:

1. Has about the same resistance to solvents and chemicals as natural rubber except that water resistance is much better.
2. Is slightly better than natural rubber in resistance to set and aging. On aging, it does not soften after severe aging as does natural rubber, but hardens and becomes brittle.
3. Does not have the resilience of natural rubber.
4. Compression and permanent set are not as good as for natural rubber. However, the cold flow characteristics are about the same.
5. The pure gum GR-S has low tensile strength. However, compounding with carbon black gives tensile strength of 2500 psi. Cold rubber tensile strength ranges to 3000 psi.
6. Has good electrical insulation properties, somewhat better than natural rubber.
7. Resistance to sunlight is about the same as for natural rubber.
8. Tensile strength is inferior to that of natural rubber.
9. Abrasion resistance is equal to or better than that of natural rubber. However, cold rubber has the best abrasion resistance of the GR-S polymers.
10. Burns readily and emits pungent odor.
11. Costs less than neoprene.

Butyl: A copolymer of about 98 per cent isobutylene and 2 per cent isoprene, butyl is consumed primarily in the manufacture of inner tubes. Butyl rubber exhibits the following properties and characteristics:

1. Has the poorest resistance to petroleum oils and gasoline.
2. Excellent resistance to corrosive chemicals.
3. Outstanding for resistance to dilute mineral acids.
4. Excellent resistance to mineral oils.
5. Excellent resistance to solvents such as acetone, alcohol, phenol, and ethylene-glycol.
6. Excellent resistance to water absorption.
7. Excellent heating resistance. Heat aging similar to that of natural rubber. It hardens and then softens with severe aging.
8. Fair flexibility at low temperature.
9. Resilience is poor at low temperatures, but at temperatures of about 200 F it closely approaches natural rubber.
10. Fair compression and permanent set characteristics.
11. Tensile strength properties rank third behind natural rubber and neoprene.
12. Exhibits very good electrical insulation properties.
13. Excellent resistance to sunlight.
14. Tear resistance slightly better than natural rubber.
15. Abrasion resistance not as good as that of natural rubber.
16. Possesses the characteristic of having low permeability to gases. Better than natural rubber.

Reclaim: The lowest-cost material available, reclaim rubber is the product resulting from the processing of waste vulcanized rubber by mechanical, thermal, and chemical treatments. It is used in great quantities in the processing of Grade R materials. Compounds having substantial portions of reclaim rubber will tend to retain their shape in the uncured state better than those compounds having no reclaim rubber. As a result, forming processes in the uncured state, such as calendering, tubing coating, or cutting of blanks for molds, are more easily performed when reclaim is present in the compound.

Grade SC

Neoprene: A polymer of chloroprene, neoprene is the most used of the synthetic rubbers. It more closely resembles natural rubber than any of the other synthetics mentioned here. It has a number of qualities not possessed by natural rubber: resistance to oil, sunlight, ozone, oxidation, and heat. It is

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flame resistant in that it does not support combustion. Neoprene exhibits the following properties and characteristics:

1. Most commonly used synthetic where resistance to gas or oil is required. Although resistance to the swelling action of aromatic solvents and gas containing aromatics is poor, it is, nevertheless, much better than natural rubber.
2. Resistance to the swelling action of oxygenated solvents is poorer than that of natural rubber, but better than nitrile rubbers.
3. Resistance to the corrosive action of chemicals is best of the synthetics with the exception of butyl.
4. Resistance to water absorption is comparable to that of natural rubber.
5. Exhibits good heat resistance and does not soften like natural rubber under severe heat.
6. Resilience is about as good as that of natural rubber.
7. Compression set and permanent set characteristics of neoprene GN are not as good as that of natural rubber. However, Type W neoprene has a very low set, equal to or better than natural rubber.
8. Cold flow resistance is good.
9. Is the closest match to the tensile properties of natural rubber as compared to all other synthetics.
10. In the pure gum state, tensile strength is higher than natural rubber. How-

Relative Properties of Natural and Synthetic Rubber

Property	Natural Rubber	Grade R GR-S or Buna S	Butyl	Grade SA Thiokol (GR-P)	Grade SB Nitrile (Buna N)	Grade SC Neoprene (GR-M)	Grade T Silicone
Composition	.....	Butadiene-styrene	Isobutylene isoprene	Organic polysulfide	Butadiene-acrylonitrile	Chloroprene	Polysiloxane polymer
Tensile Strength (psi)							
Pure Gum	Over 3000	Below 1000	Over 1500	.....	Below 1000	Over 3000	Below 1500
Black Load Stocks	Over 3000	Over 2000	Over 2000	.....	Over 2000	Over 3000	.....
Hardness Range (Shore Durom A)	30–90	40–90	40–75	35–80	40–95	40–95	40–85
Specific Gravity (Base Material)	0.93	0.94	0.92	1.34	1.00	1.23	.....
Tear Resistance	Good	Fair	Good	Poor	Fair	Good	Poor
Abrasion Resistance	Excellent	Good to excellent	Good	Poor	Good	Excellent	Poor
Solvent Resistance							
Aliphatic hydrocarbons	Poor	Poor	Poor	Excellent	Excellent	Good	Poor
Aromatic hydrocarbons	Poor	Poor	Poor	Good	Good	Fair	Poor
Acid Resistance							
Dilute	Fair to good	Fair to good	Excellent	Fair	Good	Excellent	Excellent
Concentrated	Fair to good	Fair to good	Excellent	Fair	Good	Good	Fair
Oxygenated solvents (ketones, etc.)	Good	Good	Good	Good	Poor	Poor	Fair
Permeability to Gasses	Fair	Fair	Very low	Low	Fair	Low	Fair
Oil and Gasoline Resistance	Poor	Poor	Poor	Excellent	Excellent	Good	Fair
Animal and Vegetable-Oil Resistance	Poor to good	Poor to good	Excellent	Excellent	Excellent	Good	Fair
Oxidation	Good	Good	Excellent	Good	Good	Excellent	Excellent
Sunlight Aging	Poor	Poor	Very good	Good	Poor	Very good	Excellent
Heat Aging	Good	Very good	Excellent	Fair	Excellent	Excellent	Outstanding
Resistance to Swelling in Lubricating Oil	Poor	Poor	Poor	Excellent	Very good	Good	Fair
Resistance to Water Absorption	Very good	Good to very good	Very good	Fair	Fair to good	Good	Good
Resistance to Lacquer Solvents	Poor	Poor	Poor	Good	Fair	Poor	Poor
Flame Resistance	Poor	Poor	Poor	Poor	Poor	Good	Fair
Cold Resistance	Excellent	Excellent	Good	Fair	Good	Good	Excellent
Heat Resistance	Good	Excellent	Excellent	Poor	Excellent	Excellent	Excellent
Ozone Resistance	Fair	Fair	Excellent	Excellent	Fair	Excellent	Excellent
Rebound							
Cold	Excellent	Good	Bad	Fair	Good	Very good	Excellent
Hot	Excellent	Good	Very good	Fair	Good	Very good	Excellent
Dielectric Strength	Excellent	Excellent	Excellent	Fair	Poor	Good	Good
Electrical Insulation	Good to excellent	Good to excellent	Good to excellent	Fair to good	Poor	Fair to good	Excellent
Compression Set	Good	Good	Fair	Poor	Good	Fair to good	Fair
Vulcanizing Properties	Excellent	Excellent	Good	Fair	Excellent	Excellent	.....
Adhesion to Metals	Excellent	Excellent	Good	Poor	Excellent	Excellent	.....
Adhesion to Fabric	Excellent	Good	Good	Fair	Good	Excellent	.....

ever, compounding with carbon black or light-colored pigments gives tensile strength not as high as that of natural rubber.
11. Excellent resistance to sunlight and ozone. Butyl rubber is the only equal to neoprene in these properties.
12. Tear resistance equals that of natural rubber but is very poor at elevated temperatures.
13. Flame resistance is excellent.
14. Abrasion resistance is excellent.
15. Less expensive than nitrile rubber.
16. Extremely well suited for dipped goods, such as a rubber coating applied to cloth.

Grade SB

Nitrile Rubber (Buna N or GR-A): A copolymer of butadiene and acrylonitrile, the nitrile type of rubber is used primarily for applications requiring excellent resistance to petroleum oils and gas. It has good resistance to aromatic hydrocarbons, better than neoprene, but not as good as Thiokol. Special compounding of nitrile can give oil-resistance values approaching those of Thiokol. It possesses excellent resistance to mineral and vegetable oils but poor resistance to the swelling action of oxygenated solvents such as acetone. In addition, nitrile rubber exhibits the following properties and characteristics:

1. Good resistance to acids and bases with the exception of those having oxidizing action on materials.
2. Good heat resistance; commonly used in hot oil applications.
3. Cold resistance not as good as that of natural rubber, but it can be compounded to give freeze resistance as good as that of natural rubber.
4. Good resilience, but not to be compared with natural rubber.
5. Good permanent set characteristics and cold flow resistance.
6. Poor tensile strength in the pure gum state; however, compounding with phenolic resins will give hard compounds with tensile strength up to 5000 psi.
7. Does not have the electrical insulation characteristics of natural rubber, GR-S, or butyl.
8. Does not have the sunlight resistance of neoprene and butyl, but can be compounded to give good resistance.
9. Tear resistance is poorer than that of natural rubber.
10. Abrasion resistance not as good as natural rubber, GR-S, or Neoprene.
11. Costs more than neoprene.
12. Burns readily; emits a heavy smoke with a very oily odor. Residue after burning is a slightly tacky ash.

Grade SA

Thiokol: An organic polysulfide, Thiokol can be prepared by reacting an ethylene dichloride with sodium tetrasulfide. The Thiokol material has the most outstanding resistance, over all the rubbers, to the swelling action of oils, greases and all solvents. It exhibits poor tensile characteristics and has a very objectionable odor. It lacks in resilience and only exhibits fair heat resistance with a tendency to harden with heat and shelf aging. Recently some odorless polymers have been developed.

Grade T

Silicone Rubber: A polysiloxane polymer, silicone type rubber exhibits outstanding resistance to both heat and cold, can be exposed continuously to temperatures to 400 F, to temperatures of 500 F for short periods of time, and to temperatures as low as −110 F. Grade T is actually specified under ASTM as Grade TA and Grade TB. The TA material is specially compounded to exhibit maximum resistance to the effects of both high and low temperatures. The TB material is compounded to have outstanding resistance to both dry heat and oils at high temperatures. For most properties, such as tensile strength, tear resistance, and abrasion resistance, the silicone type polymers are particularly poor. Unless its outstanding characteristics are mandatory, the cost of this material is generally prohibitive.

Sponge and Foam Rubber

The properties of blown sponge and latex foam rubber are similar to those of solid rubber and are related to the basic polymer and fillers used. Heat, sunlight, excessive cold temperatures, acids, oils, etc., all affect the life of sponge and foam in approximately the same manner as they do solid rubber. As the names sponge or foam imply, tensile strength is not inherent nor is it important, since these types are used primarily for cushioning, weather stripping, insulation, or sound and vibration damping.

Sponge Rubber: Two grades of sponge rubbers are produced: open-cell and closed-cell. Open-cell sponge rubbers are made by incorporating into the compound an inflating agent, such as sodium bicarbonate, that gives off a gas which expands the mass during the vulcanizing process. The resulting product contains cells or small hollow receptacles which are open and interconnecting.

Closed-cell (expanded) rubbers are made by subjecting the compound to a gas, such as nitrogen, at a high temperature. Under these conditions, a certain amount of gas dissolves in the compound. When the pressure is lowered, the mass expands and the product consists of myriads of individual nonconnecting, gas type cells. This type of material is particularly suited for gasketing or dust-proofing applications.

Both the open-cell and closed-cell rubbers are manufactured in strip and sheet, and molded into special shapes. Limited manufacturing by extrusion is currently being done and promises to be expanded considerably in the future. Both the open and closed-cell rubbers are normally supplied with a natural skin on both sides. When this type of material is to be bonded to another material, it should be slit on the bonding side to afford maximum adhesion strength.

Foam Rubber: Latex foam rubbers are similar to sponge. However, the foam is produced by beating the liquid latex in a vat, much like beating egg whites with a beater. The structure of latex foam rubber consists of a network of open or interconnecting cells, and the vulcanized structure has a porous surface. Like sponge rubber, latex foam rubbers are manufactured in sheet, strip, molded, or specific shapes. At this time there are no published specifications for oil-resistant type latex foam; however, latex foam rubber may be made from neoprene latex. Both the sponge and foam rubbers are available with varying degrees of firmness.

PROCESSES

Calendering

A form of operation by which rubber compounds are sheeted or spread upon fabrics, calendering involves milling the uncured rubber into flat continuous sheets or pressing it into a piece of fabric by passing it through the bite of large steel rolls. The work done on the calender is of three general types:

1. Sheeting—production of long continuous sheets of compound.
2. Frictioning—mechanical shearing of a thin layer of rubber into a sheet of fabric.
3. Skim coating—application of a thin sheet of rubber to a sheet of fabric which has usually already been frictioned.

Extruding

In the extruding or tubing process, uncured rubber stock is run into long continuous strips of a specified cross section. The extrusion usually consists of tubing, channel rubber, and wire covering, and is almost always done in screw type

machines where strips of warmed stock are fed into the barrel mouth and forced by the screws into the head and out through the die.

Advantages
1. Low setup and die cost.
2. Low finished part cost.
3. Extruded strips can be cut to length and vulcanized endless to form gaskets, etc.

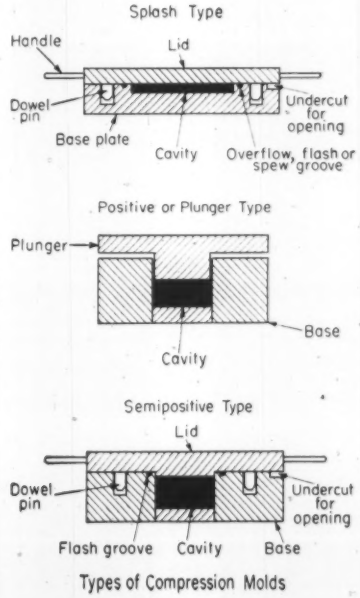
Disadvantages
1. Moderate tolerances required.
2. Considerable design limitations.
3. Durometer hardness limited from 40 to 90.
4. Limited in size (4-inch diameter max.)

Compression Molding

Rubber parts and products are most commonly produced by compression molding. The mold generally consists of two plates of steel in which a cavity or cavities have been formed to the size and shape of the article being molded, with allowances for shrinkage. The mold is charged with a slug of unvulcanized rubber which is slightly greater in weight and volume than the finished article and varies in consistency from fresh putty to that of a crepe sole, depending upon the compound. The mold is closed and pressure and heat are applied, forcing the slug into the cavity. Since the slug is slightly larger than the mold, the rubber is forced to follow every contour of the cavity. The excess rubber forms a "flash" between the two plates. This flash is removed by trimming after molding.

This description is of an elementary nature; some complex parts may require more than two plates and also may require the use of cores and inserts, which form holes, recesses, etc.

Advantages
1. Molds are less costly than transfer molds.



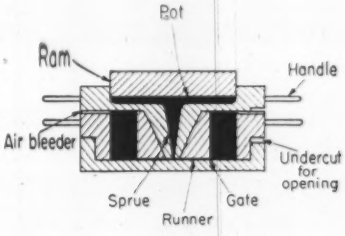
Types of Compression Molds

2. Close tolerances on all dimensions except at parting line.
3. Can be operated with less labor cost than other types.
4. Uniformity and good finish.
5. More than one cavity per mold usually can be run.
6. High tensile, tear, and shear properties obtained from bonding during the vulcanization process..

Disadvantages
1. Parts vary in thickness since the "flash" thickness varies with the weight of the slug.
2. Trimming is necessary, whereas other types of molding do not require trimming.
3. Tolerance of ±0.005-inch minimum required on thickness.

Transfer Molding

In transfer molding, the mold is closed before the rubber compound is loaded into it. The top plate of the mold carries a ram, which fits into a pot and into the top of the center plate of a three-piece mold. The center and bottom plates contain between them the cavity, which forms the finished article, and are closed together as the first step in molding. The top of the center plate contains the pot into which the mixed, uncured stock is placed, and



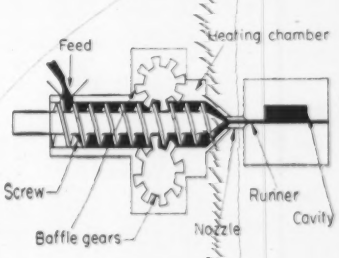
sprues or holes run between this pot and the cavity. When the press is closed, the ram, which is carried by the top plate, fits into the pot and forces the rubber through the sprues and into the cavity.

Advantages
1. Uniformity and good finish.
2. Permits molding of a part which would be practically impossible to make by compression molding.
3. Reduction to a minimum of the variation in thickness of the molded article, making possible the holding of tolerances otherwise unobtainable at reasonable cost.
4. Practically eliminates flash.
5. Makes possible the use of thin cores and inserts that form holes, etc., and finished articles which might not be practical in compression molding because: *(a)* the mold is closed and the thin cores or inserts are anchored firmly in place before the pressure of rubber stock is exerted against them, and *(b)* the rubber stock in a transfer mold is thoroughly heated and softened as it presses through the hot sprues before hitting any cores or inserts in the cavity, which is unlike compression molding.

Disadvantages
1. Higher initial cost of mold.
2. Limited output per mold.
3. Not all compounds will flow suitably for this method.
4. Bonding to inserts, etc., not as good as with compression molding.

Injection Molding

A relatively new process, injection molding involves running a mold which is closed in the press. Material is injected under pressure into the closed mold to fill the cavity. Equipment and maintenance are



costly and generally prohibit the use of this method for general production. It has the benefit of precision and close tolerances, which are approximated by transfer molding using regular press equipment.

Rubber Latex Dip Coating

The most widely used type of rubber latex for dip coating is natural rubber and neoprene. Some use is made of GR-S material. Although the method of fabrication differs widely from the conventional dry rubber elastomers, for all practical purposes the regular ASTM rubber specifications apply. However, tensile strength and per cent elongation, for instance, are much higher for the dip rubber parts than for the milled dry rubber. For coating tool handles, impregnation of fabric material or other similar type applications where tolerances and physical properties are not of major importance, the regular rubber specifications are entirely suitable. For those applications where physical properties are of a critical nature, these requirements should be spelled out on the part drawing.

For the most part, this discussion has been limited to the dipping of a part into a liquid latex. A form or a mandrel also may be submerged in the latex and a particular shape (such as a glove) created.

This type of dipping has its limitations in that the thickness of the dipped part must of necessity be the same throughout, except for a few specialized applications.

The major advantages of latex coating over compression molding are that there is no flash, and the tool costs on the dipping type of fabrication as well as the part price

are appreciably less.

Rubber may be applied by the dip method to a variety of materials such as metal, paper, fabrics, ceramic, etc. Normal coatings range in thickness from less than 0.005 to 0.060-inch and the thickness may be built up by subsequent dips. Generally, the tolerances on dipped goods are equal to or lower than those of compression molding. Commercial tolerances on latex films in the thickness range of 0.015-inch or less would be plus or minus 10 per cent.

DESIGN

Commercial Tolerances

Close tolerances are difficult to maintain and costly, and should be restricted to those dimensions that affect the process control and function of a part. The following tables give commercial tolerances (in inches) for sheet and slab, extrusions, and lathe and automatic cut components.

Molded Parts

The following suggestions are a brief outline of points to consider in the mechanical design of molded rubber parts.

1. Unnecessarily close tolerances create additional mold and product cost. Recommended tolerances are:

a. Dimensions not affected by mold parting line—±0.005-inch or ±½ per cent of specified dimensions, whichever is greater

b. Dimensions that cross a mold parting line— allow for conventional compression molded components, ±0.010-inch, in addition to *a*, and for transfer and injection molded parts, ±0.005-inch in addition to *a*.

2. Molded articles shrink while being vulcanized. Have supplier advise approximate shrinkage anticipated. Loaded compounds normally shrink about 0.016-inch per inch. Nonloaded stocks (pure gum, etc.) shrink about 0.030-inch per inch.

3. If possible, design molded parts so that mold parting line (trim or overflow point) is not on a radius.

4. Design parts with slight draft instead of straight sides to facilitate removal of part from mold.

5. Eliminate beads, radii, undercuts, etc., unless absolutely necessary. Keep design as simple as practical to save on mold and parts cost.

6. On conventional compression-molded parts, the mold parting line must be at the largest diameter for proper and economical trimming.

7. Avoid fragile edges. Allow $\frac{1}{16}$-inch flange depth minimum in preference to feather edges.

8. Avoid incorporation of inserts (metal, cloth, etc.) when purpose for which insert is needed (usually reinforcement) can be accomplished by other means.

Relative Costs

To provide a picture of costs of the various polymers, a molded part is taken as an example with the following comparative results:

Reclaim	60–85
GR-S	100
Butyl	105–110
Natural Rubber	110–115
Neoprene	110–125
Nitrile	120–150
Thiokol	240–300
Silicone	1000

Natural rubber can fluctuate appreciably higher due to market conditions.

Commercial Tolerances on Extrusions

Inside Diam.	Tol.	Outside Diam.	Tol.
$\frac{1}{32}$ to ½	±0.008	$\frac{1}{16}$ to ½	$\pm\frac{1}{64}$
$\frac{33}{64}$ to 1	$\pm\frac{1}{64}$	$\frac{3}{64}$ to 1	$\pm\frac{1}{32}$
1 to 3	$\pm\frac{1}{32}$	$1\frac{1}{64}$ to 2	$\pm\frac{3}{64}$
		2 to 4	$\pm\frac{1}{16}$

Commercial Tolerances on Thickness of Sheet and Slab

Thickness	Tol.	Thickness	Tol.
$\frac{1}{64}$, $\frac{1}{32}$	±0.008	⅛, ¾, 1	±0.047
$\frac{3}{32}$, $\frac{1}{16}$, ⅛	±0.016	1¼, 1½, 2	±0.063
$\frac{3}{16}$, ¼, ⅜	±0.031		

Above data excludes sponge and foam, which require a tolerance of ±10 per cent of the designated thickness or $\pm\frac{1}{32}$-inch, whichever is greater. This recommendation is for thicknesses of ⅛-inch and up.

Commercial Tolerances on Lathe-Cut Parts

ID	Tol.	OD	Tol.	Thick. (cut)	Tol.
Mandrel cure	+0, −0.010	Ground finish	±0.010	$\frac{1}{16}$ to $\frac{3}{16}$	±0.015
Pan cure	±0.031	Unground		¼ to ⅜	±0.025
		under 1½	±0.031	½ to 1	±0.031
		over 1½	±0.062	1 and up	by agreement

Commercial tolerance on Durometer hardness of rubber is ±5.

Tips and Techniques

Preventing Ink Blots

In using circle templates for making ink drawings, there is always a danger of ink running beneath the template and ruining a partially completed drawing. One common method of avoiding this trouble is to raise the template slightly using razor blades or thin cardboard. A more convenient method is to have the holes enlarged by about 1/16-in. in an old set of circle templates. Cement the old templates to the underside of a new set. Thus, the edges of the smaller circles are raised above the paper and the necessity of moving assorted pieces of "hardware" around the drawing is eliminated.—CLIFFORD MOLLOY, *Bronx, N. Y.*

A long thin strip of cardboard or thin metal rule may be taped or cemented to the underside of a triangle parallel to the working edge and about 1/32-in. from the edge. This serves to raise the edge of the triangle slightly off the paper and prevent ink from seeping under the edge.—D. J. COLOCCIA, *Wheeler Laboratories Inc., Great Neck, N. Y.*

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MACHINE DESIGN
Data Sheet

Design Tables *for* Helical Compression Springs

By Edwin F. Smith
Steam Division
Westinghouse Electric Corp.
South Philadelphia, Pa.

SPRING design is often tedious because of the large number of variables that must be manipulated in a search for the best solution. This article presents an extensive series of tables aimed at simplifying the design of helical compression springs.

The tables present four design constants for a wide range of mean spring diameters and wire diameters. Mean spring diameters range from 0.08 to 11 inches; wire diameters from 0.014 to 1.5 inches.

The four constants, identified as *A*, *B*, *C*, and *D*, are defined in *Table* 1. As shown under *Basic Terms*, the constants have been calculated from conventional spring formulas, including the curvature-correction factor. Also see *Nomenclature* and the accompanying sketch.

Only one attribute of the spring material is built into the design constants. It is the modulus of rigidity, *G*, which has been taken at 11,500,000 psi for carbon steels. *Table* 2 shows the modulus for various materials. Constants *B*, *C*, and *D* must be reduced by proportional amounts if a material having a lower modulus is used. *Table* 2 provides "multipliers" for materials other than carbon steel.

The constants do not include any recommended

Nomenclature

C = Spring index
$= 2\,r/d$
d = Wire diameter, in.
G = Modulus of rigidity, psi
$= 11{,}500{,}000$ psi in accompanying tables
K = Curvature correction factor
$= [(4c-1)/(4c-4)] + (0.615/c)$
l = Length of spring, closed, between ends of active coils, in.
$= n\,d$
n = Number of active coils
P = Axial load, lb
r = Mean radius of spring, in.
δ = Deflection, in.
σ = Tortional shearing stress, psi

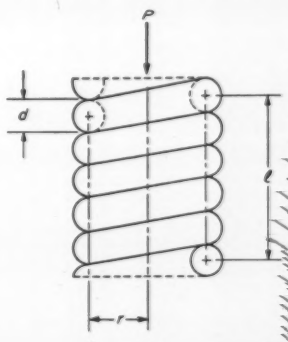

Table 1—Meaning of Design Constants

Design Constant	Spring Characteristic	Basic Terms*	Significance of Constant
$A =$	$\frac{\sigma}{P} =$	$K\frac{16r}{\pi d^3}$	Stress per lb of load
$B =$	$\frac{P}{\delta}n =$	$\frac{G d^4}{64 r}$	Relates spring rate (load per in. of deflection) and number of active coils
$C =$	$\frac{P}{\delta}l =$	$\frac{G d^5}{64 r^3}$	Relates spring rate and closed length
$D =$	$\frac{\sigma l}{\delta} = \frac{\sigma}{P}\frac{P}{\delta}l =$	$K\frac{G d^2}{4\pi r^2}$	Useful in design of multiple-spring systems

*Data in accompanying tables are computed from these terms.

Table 2—Modulus of Rigidity

Spring Material	Modulus, G (psi)	Multiplier for B, C and D
Carbon steel (music wire, oil-tempered wire)	11,500,000	1
Hot-wound springs, heat treated after coiling	10,500,000	0.9
Hard-drawn stainless steel	10,500,000	0.9
Monel metal	9,000,000	0.8
Phosphor bronze	6,000,000	0.6

Table 3—Stress at Solid Compression

Spring Material (diam in.)	Recommended Stress (1000 psi) With No Set	With Set Removed
Music Wire		
up to 0.032 diam.	130	180
0.032 to 0.062	110	170
0.062 to 0.125	100	160
0.125 and over	90	150
Hard-Drawn Spring Wire		
up to 0.032 diam	120	170
0.032 to 0.062	100	160
0.062 to 0.125	90	150
0.125 and over	80	140
Oil-Tempered Wire		
0.125 diam and over	80	140
18-8 Stainless (hard-drawn)		
up to 0.125 diam	85	140
0.125 and over	75	120
Phosphor Bronze		
(general sizes)	40	70

From *Kent's Mechanical Engineers Handbook, Design and Production*, 12th Edition, John Wiley and Sons Inc., New York, 1950, Page 11-18.

Coil pitch should be chosen so no permanent set occurs when the spring is compressed solid. Second column gives stress at solid compression up to which no permanent set will occur. Last column lists maximum stress at solid compression if all set is removed by repeated cycling.

stress level. For convenience, suggested stress values are presented in *Table* 3.

The spring design tables may be used in different ways. Several typical design situations are demonstrated in the following examples.

Example 1: Find a spring that will support 110 lb. Maximum allowable stress is 60,000 psi.

From *Table* 1, constant $A = \sigma/P = 60{,}000/110 = 545$. Any combination of wire and mean spring diameters in the tables having $A = 545$ satisfies the condition. Usually, of course, a precise fit will not be found. Then, a value of A less than that required should be selected. Such a choice means that the stress will be slightly less than that specified.

In this case, $A = 518.9$ is picked, at 1.5-in. mean spring diameter and 0.207-in. wire diameter. Checking the stress shows that $\sigma = AP = 518.9(110) = 57{,}000$ psi.

Example 2: What is the number of active coils for *Example* 1 if spring rate $P/\delta = 60$ lb per in.?

For the same spring and wire diameters as selected in *Example* 1, $B = 782.3$. From *Table* 1, $B = (P/\delta)n$. Therefore, $n = B/(P/\delta) = 782.3/60 = 13$ active coils. This answer, of course, must be increased in accordance with end coil conditions of the application.

Example 3: The spring of *Examples* 1 and 2 is required to have a length of 2.75 in. Will this spring meet the length requirement?

Constant $C = (P/\delta)\,l$ from *Table* 1, or $C = 60\,(2.75) = 1.65$. Thus, the spring must satisfy these conditions: $C \leqq 165$ and $A \leqq 545$. A spring with 0.207-in. mean diameter and 0.207-in. wire diameter satisfies both conditions ($C = 162$, $A = 518.9$).

Length $l = C/(P/\delta) = 162/60 = 2.7$ in.

Example 4: Two springs are to be nested. Find the maximum spring load under the following conditions: outside diameter = 2⅞ in. maximum; inside diameter = 1 in. minimum; length $\leqq$ 3 in. maximum; stress $\sigma = 65{,}000$ psi maximum, and working deflection $\delta = 0.75$-in.

From *Table* 1, $D = \sigma\, l/\delta = 65{,}000\,(3)/0.75 = 260{,}000$. Hence, for each spring, D must be equal to or less than 260,000.

From the spring-design tables, a combination for the larger spring is found to be: mean spring diameter = 2.25 in., wire diameter = 0.5 in. For the smaller spring, mean diameter = 1.375 in., wire diameter = 0.3065-in. The tables show that, for the larger spring, $A = 61.92$, therefore, $P = \sigma/A = 65{,}000/61.92 = 1050$ lb. For the smaller spring, $A = 164.4$ and $P = 65{,}000/164.4 = 395$ lb. Therefore, the maximum spring load is 1050 + 395 = 1445 lb.

Wire Dia. (in.)		Mean Diameter of Spring (in.)													
		0.080	0.100	0.120	0.140	0.160	0.180	0.200	0.220	0.240	0.260	0.280	0.300	0.320	0.340
0.014	A	94643	112122	130383	148739										
	B	107.9	55.24	31.97	20.13										
	C	1.51	0.773	0.448	0.282										
	D	142054	86714	58355	41922										
0.015	A	77768	92398	107202	122099	137048	152032	167039							
	B	142.2	72.80	42.13	26.53	17.77	12.48	9.100							
	C	2.13	1.09	0.632	0.398	0.267	0.187	0.136							
	D	165862	100896	67745	48589	36537	28466	22800							
0.0162	A	63009	74547	86255	98051	109897	121776	133677							
	B	193.4	99.04	57.32	36.09	24.18	16.98	12.38							
	C	3.13	1.60	0.929	0.585	0.392	0.275	0.201							
	D	197454	119609	80089	57332	43049	33503	26810							
0.0173	A	52720	62130	71707	81368	91078	100819	110581	120358	130145	139940				
	B	251.6	128.8	74.54	46.94	31.45	22.09	16.10	12.10	9.318	7.329				
	C	4.35	2.23	1.29	0.812	0.544	0.382	0.279	0.209	0.161	0.127				
	D	229452	138450	92471	66078	49550	38522	30802	25188	20979	17742				
0.0181	A	46670	54842	63178	71597	80064	88561	97078	105610	114151	122701				
	B	301.4	154.3	89.32	56.25	37.68	26.46	19.29	14.49	11.16	8.781				
	C	5.46	2.79	1.62	1.02	0.682	0.479	0.349	0.262	0.202	0.159				
	D	254635	153203	102135	72889	54605	42421	33899	27707	23067	19502				
0.0204	A	33919	39524	45286	51128	57015	62930	68864	74810	80767	86730	92699	98672	104649	
	B	486.4	249.0	144.1	90.76	60.80	42.70	31.13	23.39	18.02	14.17	11.35	9.224	7.600	
	C	9.92	5.08	2.94	1.85	1.24	0.871	0.635	0.477	0.368	0.289	0.231	0.188	0.155	
	D	336578	200801	133148	94664	70719	54821	43733	35695	29683	25070	21454	18587	16225	
0.023	A	24771	28579	32542	36582	40664	44772	48899	53037	57184	61337	65496	69659	73824	77992
	B	786.0	402.4	232.9	146.7	98.24	69.00	50.30	37.79	29.11	22.90	18.33	14.90	12.28	10.24
	C	18.1	9.26	5.36	3.37	2.26	1.59	1.16	0.869	0.670	0.527	0.422	0.343	0.282	0.235
	D	447788	264507	174301	123389	91885	71055	56572	46101	38286	32300	27615	23879	20852	18366
0.0258	A		21048	23801	26629	29498	32392	35303	38225	41155	44091	47031	49976	52923	55872
	B		637.1	368.7	232.2	155.5	109.2	79.64	59.84	46.09	36.25	29.02	23.60	19.44	16.21
	C		16.4	9.51	5.99	4.01	2.82	2.05	1.54	1.19	0.935	0.749	0.609	0.502	0.418
	D		345986	226420	159526	118384	91302	72540	59011	48937	41237	35218	30427	26549	23368
0.0286	A		16070	18043	20088	22174	24284	26410	28546	30690	32840	34994	37151	39312	41474
	B		962.1	556.8	350.6	234.9	165.0	120.3	90.36	69.60	54.74	43.83	35.63	29.36	24.48
	C		27.5	15.9	10.0	6.72	4.72	3.44	2.58	1.99	1.57	1.25	1.02	0.840	0.700
	D		442189	287304	201442	148963	114576	90837	73768	61088	51413	43864	37862	33011	29035
0.03175	A			13677	15143	16647	18175	19718	21271	22832	24398	25968	27541	29117	30694
	B			845.6	532.5	356.8	250.6	182.7	137.2	105.7	83.14	66.57	54.12	44.59	37.18
	C			26.8	16.9	11.3	7.96	5.80	4.36	3.36	2.64	2.11	1.72	1.42	1.18
	D			367225	256031	188563	144590	114355	92684	76628	64404	54883	47325	41226	36233
0.0348	A			10765	11851	12976	14124	15287	16460	17639	18824	20012	21204	22398	23594
	B			1220	768.6	514.9	361.6	263.6	198.1	152.6	120.0	96.07	78.11	64.36	53.66
	C			42.5	26.7	17.9	12.6	9.17	6.89	5.31	4.18	3.34	2.72	2.24	1.87
	D			457224	316978	232510	177748	140245	113450	93648	78604	66908	57638	50166	44057
0.041	A				7711	8371	9053	9750	10457	11169	11887	12608	13332	14058	14786
	B				1481	992.1	696.7	507.9	381.6	293.9	231.2	185.1	150.5	124.0	103.4
	C				60.7	40.7	28.6	20.8	15.6	12.1	9.48	7.59	6.17	5.08	4.24
	D				468170	340477	258629	203051	163605	134608	112675	95687	82264	71475	62674
0.0475	A				5302	5700	6121	6556	7001	7452	7908	8366	8828	9292	9757
	B				2668	1787	1255	915.0	687.5	529.5	416.5	333.5	271.1	223.4	186.3
	C				127	84.9	59.6	43.5	32.7	25.2	19.8	15.8	12.9	10.6	8.85
	D				671834	483858	364946	284971	228623	187442	156441	132525	113691	98597	86316
0.054	A					4113	4384	4669	4963	5263	5568	5877	6187	6500	6814
	B					2985	2097	1528	1148	884.5	695.7	557.0	452.9	373.2	311.1
	C					161	113	82.5	62.0	47.8	37.6	30.1	24.5	20.2	16.8
	D					663046	496301	385324	307746	251397	209188	176759	151310	130975	114472
0.0625	A								3379	3565	3756	3951	4148	4346	4546
	B								2061	1587	1248	999.6	812.7	669.6	558.3
	C								129	99.2	78.0	62.5	50.8	41.9	34.9
	D								435130	353687	293101	246816	210666	181895	158627
0.072	A										2585	2708	2834	2961	3089
	B										2199	1760	1431	1179	983.2
	C										158	127	103	84.9	70.8
	D										409296	343280	292008	251397	218686
0.080	A										1969	2055	2144	2234	2326
	B										3351	2683	2181	1798	1499
	C										263	215	175	144	120
	D										527846	441128	374113	321268	278851

Wire Diameter: 0.014-0.080 in.
Mean Spring Diameter: 0.080-0.340 in.

Wire Dia. (in.)		Mean Diameter of Spring (in.)												
		0.360	0.380	0.400	0.420	0.440	0.460	0.480	0.500	0.520	0.540	0.560	0.580	0.600
0.023	A	82163	86335											
	B	8.625	7.334											
	C	0.198	0.169											
	D	16299	14562											
0.0258	A	58824	61777	64731										
	B	13.66	11.61	9.955										
	C	0.352	0.300	0.257										
	D	20725	18507	16626										
0.0286	A	43638	45804	47971										
	B	20.62	17.53	15.03										
	C	0.590	0.501	0.430										
	D	25736	22969	20625										
0.03175	A	32274	33855	35436	37019	38603	40187	41772	43358	44944	46530			
	B	31.32	26.63	22.83	19.72	17.15	15.01	13.21	11.69	10.39	9.280			
	C	0.994	0.846	0.725	0.626	0.545	0.477	0.420	0.371	0.330	0.295			
	D	32094	28625	25689	23182	21025	19155	17524	16093	14830	13710			
0.0348	A	24791	25990	27190	28390	29592	30794	31996	33200	34403	35607	36812	38016	39221
	B	45.20	38.43	32.95	28.47	24.76	21.67	19.07	16.87	15.00	13.39	12.01	10.81	9.764
	C	1.57	1.34	1.15	0.991	0.862	0.754	0.664	0.587	0.522	0.466	0.418	0.376	0.340
	D	38998	34762	31180	28124	25496	23219	21234	19493	17957	16596	15384	14300	13327
0.041	A	15515	16245	16977	17709	18442	19175	19909	20643	21378	22113	22848	23584	24320
	B	87.09	74.05	63.49	54.85	47.70	41.75	36.74	32.51	28.90	25.81	23.14	20.83	18.81
	C	3.57	3.04	2.60	2.25	1.96	1.71	1.51	1.33	1.18	1.06	0.949	0.854	0.771
	D	55402	49324	44193	39821	36068	32820	29992	27513	25330	23396	21675	20138	18758
0.0475	A	10223	10691	11159	11628	12098	12568	13039	13510	13981	14453	14925	15397	15870
	B	156.9	133.4	114.4	98.81	85.94	75.21	66.19	58.56	52.06	46.49	41.68	37.52	33.89
	C	7.45	6.34	5.43	4.69	4.08	3.57	3.14	2.78	2.47	2.21	1.98	1.78	1.61
	D	76191	67745	60627	54574	49382	44897	40995	37581	34575	31916	29551	27440	25547
0.054	A	7129	7446	7763	8081	8399	8718	9037	9357	9677	9998	10318	10639	10960
	B	262.1	222.8	191.1	165.0	143.5	125.6	110.6	97.82	86.96	77.65	69.63	62.67	56.61
	C	14.2	12.0	10.3	8.91	7.75	6.78	5.97	5.28	4.70	4.19	3.76	3.38	3.06
	D	100896	89596	80089	72017	65104	59140	53958	49427	45443	41922	38794	36003	33503
0.0625	A	4748	4950	5153	5356	5560	5765	5970	6175	6380	6586	6792	6998	7205
	B	470.3	399.9	342.8	296.2	257.6	225.4	198.4	175.5	156.1	139.3	124.9	112.5	101.6
	C	29.4	25.0	21.4	18.5	16.1	14.1	12.4	11.0	9.75	8.71	7.81	7.03	6.35
	D	139545	123703	110408	99142	89513	81220	74025	67745	62230	57361	53041	49190	45744
0.072	A	3219	3349	3480	3612	3744	3877	4010	4144	4277	4411	4545	4680	4814
	B	828.3	704.3	603.8	521.6	453.7	397.0	349.4	309.2	274.8	245.4	220.1	198.1	178.9
	C	59.6	50.7	43.5	37.6	32.7	28.6	25.2	22.3	19.8	17.7	15.8	14.3	12.9
	D	191953	169828	151310	135657	122308	110833	100896	92236	84643	77949	72017	66736	62015
0.080	A	2419	2513	2607	2702	2798	2894	2990	3087	3184	3281	3378	3476	3573
	B	1262	1073	920.3	795.0	691.5	605.1	532.6	471.2	418.9	374.1	335.4	301.9	272.7
	C	101	85.9	73.6	63.6	55.3	48.4	42.6	37.7	33.5	29.9	26.8	24.2	21.8
	D	244294	215770	191953	171864	154763	140088	127401	116359	106690	98175	90638	83936	77949
0.0915	A		1751	1812	1875	1938	2001	2064	2128	2192	2257	2321	2386	2451
	B		1837	1575	1360	1183	1036	911.4	806.4	716.9	640.1	574.0	516.6	466.6
	C		168	144	124	108	94.8	83.4	73.8	65.6	58.6	52.5	47.3	42.7
	D		294254	261190	233389	209791	189591	172167	157034	143807	132179	121904	112780	104640
0.1055	A						1361	1402	1442	1484	1525	1567	1608	1650
	B						1830	1611	1425	1267	1131	1014	913.0	824.7
	C						193	170	150	134	119	107	96.3	87.0
	D						262773	238184	216882	198309	182017	167649	154913	143572
0.1205	A							982.1	1009	1036	1063	1090	1118	1146
	B							2741	2425	2156	1925	1726	1554	1404
	C							330	292	260	232	208	187	169
	D							324420	294854	269144	246648	226851	209340	193776
0.125	A							891.3	915.1	939.1	963.3	987.7	1012	1037
	B							3174	2809	2497	2230	1999	1799	1625
	C							397	351	312	279	250	225	203
	D							353687	321268	293101	268473	246816	227672	210665
0.135	A													842.1
	B													2211
	C													299
	D													251397
0.1483	A													655.0
	B													3220
	C													478
	D													312796

Wire Diameter: 0.023-0.1483 in.
Mean Spring Diameter: 0.360-0.600-in.

Wire Dia. (in.)		Mean Diameter of Spring (in.)											
		0.620	0.640	0.660	0.680	0.700	0.720	0.740	0.760	0.780	0.800	0.820	0.840
0.0475	A	16342	16815	17288	17761	18235	18708	19182	19655	20129			
	B	30.72	27.93	25.46	23.28	21.34	19.61	18.07	16.68	15.43			
	C	1.46	1.33	1.21	1.11	1.01	0.932	0.858	0.792	0.733			
	D	23843	22304	20910	19642	18485	17428	16459	15569	14749			
0.054	A	11281	11602	11924	12245	12567	12889	13211	13533	13855			
	B	51.30	46.64	42.53	38.89	35.65	32.76	30.17	27.85	25.77			
	C	2.77	2.52	2.30	2.10	1.93	1.77	1.63	1.50	1.39			
	C	31254	29224	27385	25714	24192	22800	21526	20355	19277			
0.0625	A	7411	7618	7825	8032	8239	8446	8653	8861	9068	9276	9483	9691
	B	92.07	83.70	76.32	69.78	63.97	58.79	54.15	49.98	46.24	42.86	39.80	37.02
	C	5.75	5.23	4.77	4.36	4.00	3.67	3.38	3.12	2.89	2.68	2.49	2.31
	D	42647	39854	37326	35031	32941	31033	29285	27681	26205	24844	23587	22422
0.072	A	4949	5084	5218	5353	5488	5624	5759	5894	6030	6165	6300	6436
	B	162.1	147.4	134.4	122.9	112.7	103.5	95.37	88.03	81.43	75.48	70.09	65.20
	C	11.7	10.6	9.68	8.85	8.11	7.45	6.87	6.34	5.86	5.43	5.05	4.69
	D	57776	53958	50505	47372	44522	41922	39542	37360	35352	33503	31794	30213
0.080	A	3671	3769	3867	3965	4063	4161	4260	4358	4457	4555	4654	4752
	B	247.1	224.7	204.9	187.3	171.7	157.8	145.4	134.2	124.1	115.0	106.8	99.38
	C	19.8	18.0	16.4	15.0	13.7	12.6	11.6	10.7	9.93	9.20	8.55	7.95
	D	72579	67745	63377	59418	55818	52535	49533	46781	44252	41922	39771	37781
0.0915	A	2516	2581	2646	2711	2776	2842	2907	2973	3038	3104	3170	3235
	B	422.9	384.5	350.6	320.6	293.9	270.1	248.7	229.6	212.4	196.9	182.8	170.1
	C	38.7	35.2	32.1	29.3	26.9	24.7	22.8	21.0	19.4	18.0	16.7	15.6
	D	97350	90794	84877	79519	74653	70219	66167	62457	59049	55912	53018	50343
0.1055	A	1692	1734	1776	1818	1861	1903	1946	1988	2031	2073	2116	2159
	B	747.5	679.6	619.6	566.6	519.4	477.3	439.6	405.8	375.4	347.9	323.1	300.6
	C	78.9	71.7	65.4	59.8	54.8	50.4	46.4	42.8	39.6	36.7	34.1	31.7
	D	133429	124322	116115	108692	101958	95829	90236	85117	80422	76103	72123	68446
0.1205	A	1173	1201	1229	1257	1286	1314	1342	1370	1399	1427	1455	1484
	B	1272	1157	1055	964.2	883.9	812.3	748.2	690.7	638.9	592.2	549.9	511.5
	C	153	139	127	116	107	97.9	90.2	83.2	77.0	71.4	66.3	61.6
	D	179881	167425	156216	146094	136922	128586	120986	114040	107674	101825	96439	91469
0.125	A	1062	1087	1112	1137	1162	1187	1212	1237	1263	1288	1314	1339
	B	1473	1339	1221	1117	1024	940.6	866.4	799.8	739.8	685.7	636.7	592.3
	C	184	167	153	140	128	118	108	100	92.5	85.7	79.6	74.0
	D	195491	181895	169666	158627	148629	139545	131267	123703	116773	110408	104548	99142
0.135	A	861.6	881.1	900.8	920.5	940.3	960.1	980.0	1000	1020	1040	1060	1080
	B	2004	1822	1661	1519	1393	1280	1179	1088	1006	932.9	866.3	805.9
	C	271	246	224	205	188	173	159	147	136	126	117	109
	D	233106	216735	202026	188762	176759	165862	155941	146881	138587	130975	123971	117514
0.1483	A	669.4	683.9	698.5	713.2	727.9	742.7	757.6	772.5	787.4	802.4	817.4	832.5
	B	2918	2653	2419	2212	2028	1863	1716	1584	1466	1358	1261	1174
	C	433	393	359	328	301	276	255	235	217	201	187	174
	D	289726	269112	250616	233959	218904	205254	192839	181513	171155	161657	152925	144881
0.162	A	529.5	540.4	551.4	562.5	573.6	584.8	596.1	607.4	618.7	630.1	641.5	653.0
	B	4156	3778	3445	3150	2888	2654	2444	2256	2087	1934	1796	1671
	C	673	612	558	510	468	430	396	366	338	313	291	271
	D	356498	330783	307746	287029	268331	251397	236013	221996	209188	197454	186678	176758
0.177	A					453.0	461.5	469.9	478.5	487.0	495.6	504.3	513.0
	B					4115	3781	3483	3215	2974	2757	2560	2381
	C					728	669	616	569	526	488	453	421
	D					329960	308859	289714	272291	256390	241838	228488	216211
0.192	A							378.7	385.2	391.8	398.5	405.1	411.9
	B							4822	4452	4118	3817	3544	3297
	C							926	855	791	733	680	633
	D							350623	329269	309802	292008	275701	260719
0.207	A								316.0	321.2	326.4	331.6	336.9
	B								6014	5564	5157	4788	4455
	C								1245	1152	1067	991	922
	D								393418	369867	348364	328679	310612
0.2253	A								253.6	257.4	261.4	265.3	269.3
	B								8440	7808	7237	6720	6251
	C								1902	1759	1630	1514	1408
	D								482172	452853	426124	401890	379295
0.2437	A										213.4	216.4	219.5
	B										9906	9199	8557
	C										2414	2242	2085
	D										515109	489123	457677

Wire Diameter: 0.0475-0.2437 in.
Mean Spring Diameter: 0.620-0.840 in.

Wire Dia. (in.)		Mean Diameter of Spring (in.)											
		0.860	0.880	0.900	0.920	0.940	0.960	0.980	1.000	1.062	1.125	1.1875	1.250
0.0625	A	9898	10106	10314									
	B	34.50	32.20	30.10									
	C	2.16	2.01	1.88									
	D	21341	20337	19402									
0.072	A	6571	6707	6843	6978	7114	7250	7386	7522				
	B	60.76	56.71	53.01	49.63	46.58	43.68	41.06	38.64				
	C	4.37	4.08	3.82	3.57	3.35	3.14	2.96	2.78				
	D	28747	27385	26117	24935	23832	22800	21834	20928				
0.080	A	4851	4950	5048	5147	5246	5345	5444	5543	5852	6161	6471	
	B	92.60	86.43	80.80	75.64	70.91	66.57	62.58	58.90	49.11	41.37	35.17	
	C	7.41	6.91	6.46	6.05	5.67	5.33	5.01	4.71	3.93	3.31	2.81	
	D	35937	34225	32632	31147	29762	28466	27254	26117	22989	20390	18208	
0.0915	A	3301	3367	3433	3499	3564	3630	3696	3762	3967	4175	4382	4588
	B	158.5	147.9	138.3	129.4	121.4	113.9	107.1	100.8	84.15	70.79	60.19	51.61
	C	14.5	13.5	12.7	11.8	11.1	10.4	9.80	9.22	7.70	6.48	5.51	4.72
	D	47866	45566	43428	41437	39580	37844	36220	34699	30545	27044	24132	21667
0.1055	A	2201	2244	2287	2330	2372	2415	2458	2501	2634	2770	2904	3039
	B	280.1	261.4	244.4	228.8	214.5	201.4	189.3	178.1	148.7	125.1	106.4	91.21
	C	29.5	27.6	25.8	24.1	22.6	21.2	20.0	18.8	15.7	13.2	11.2	9.62
	D	65044	61888	58956	56227	53684	51308	49087	47007	41334	36560	32595	29242
0.1205	A	1512	1541	1570	1598	1627	1655	1684	1713	1802	1892	1983	2073
	B	476.7	444.9	415.9	389.4	365.0	342.7	322.1	303.2	253.1	212.9	181.1	155.2
	C	57.4	53.6	50.1	46.9	44.0	41.3	38.8	36.5	30.5	25.7	21.8	18.7
	D	86872	82613	78659	74981	71555	68359	65371	62575	54959	48559	43252	38769
0.125	A	1365	1390	1416	1441	1467	1492	1518	1544	1624	1705	1785	1866
	B	552.0	515.2	481.6	450.9	422.7	396.8	373.0	351.1	292.7	246.6	209.7	179.8
	C	69.0	64.4	60.2	56.4	52.8	49.6	46.6	43.9	36.6	30.8	26.2	22.5
	D	94144	89513	85216	81220	77498	74025	70781	67745	59418	52535	46781	41922
0.135	A	1100	1121	1141	1161	1181	1201	1222	1242	1305	1369	1433	1497
	B	750.9	700.9	655.2	613.4	575.1	539.9	507.5	477.6	398.8	335.5	285.2	244.5
	C	101	94.6	88.5	82.8	77.6	72.9	68.5	64.5	53.8	45.3	38.5	33.0
	D	111546	106022	100896	96133	91699	87564	83702	80089	70261	62015	55187	49427
0.1483	A	847.6	862.7	877.9	893.0	908.2	923.4	938.7	953.9	1001	1050	1098	1146
	B	1094	1021	954.1	893.2	837.4	786.2	739.0	695.5	580.7	488.5	415.4	356.1
	C	162	151	141	132	124	117	110	103	86.1	72.4	61.6	52.8
	D	137454	130582	124212	118296	112791	107661	102873	98396	86230	76037	67609	60506
0.162	A	664.4	675.9	687.5	699.0	710.6	722.2	733.8	745.5	781.6	818.5	855.2	892.0
	B	1557	1453	1359	1272	1192	1119	1052	990.4	826.9	695.6	591.5	507.1
	C	252	235	220	206	193	181	170	160	134	113	95.8	82.1
	D	167607	159147	151310	144036	137273	130975	125099	119609	104704	92236	81941	73275
0.177	A	521.7	530.4	539.2	548.0	556.8	565.6	574.4	583.3	610.8	639.0	666.9	695.0
	B	2219	2071	1936	1813	1699	1595	1500	1411	1178	991.3	842.9	722.6
	C	393	367	343	321	301	282	265	250	209	175	149	128
	D	204894	194442	184767	175794	167458	159700	152467	145714	127401	112108	99499	88899
0.192	A	418.6	425.4	432.1	439.0	445.8	452.6	459.5	466.4	487.8	509.7	531.5	553.4
	B	3072	2868	2681	2510	2353	2209	2076	1954	1632	1372	1167	1001
	C	590	551	515	482	452	424	399	375	313	264	224	192
	D	246922	234190	222415	211503	201374	191953	183176	174987	152806	134315	119092	106313
0.207	A	342.2	347.5	352.8	358.2	363.6	369.0	374.4	379.9	396.8	414.2	431.5	448.8
	B	4151	3874	3622	3391	3179	2984	2805	2640	2204	1854	1577	1352
	C	859	802	750	702	658	618	581	547	456	384	326	280
	D	293992	278667	264507	251397	239235	227933	217411	207599	181058	158970	140814	125594
0.2253	A	273.3	277.4	281.4	285.5	289.6	293.8	297.9	302.1	315.1	328.4	341.7	355.1
	B	5825	5437	5082	4758	4461	4188	3937	3705	3093	2602	2213	1897
	C	1312	1225	1145	1072	1005	944	887	835	697	586	498	427
	D	358717	339766	322275	306097	291104	277183	264236	252172	219591	192535	170339	151763
0.2437	A	222.6	225.7	228.8	232.0	235.2	238.4	241.6	244.8	255.0	265.4	275.8	286.2
	B	7974	7443	6958	6514	6107	5733	5389	5072	4235	3562	3029	2597
	C	1943	1814	1696	1587	1488	1397	1313	1236	1032	868	738	633
	D	432492	409327	387970	368239	349972	333029	317283	302626	263105	230361	203551	181152
0.2625	A			188.6	191.0	193.5	196.0	198.6	201.1	209.1	217.3	225.5	233.8
	B			9366	8768	8220	7717	7254	6828	5700	4795	4077	3496
	C			2459	2302	2158	2026	1904	1792	1496	1259	1070	918
	D			463588	439688	417587	397108	378096	360415	312821	273483	241342	214538
0.283	A								165.2	171.4	177.8	184.3	190.8
	B								9224	7701	6478	5508	4723
	C								2610	2179	1833	1559	1336
	D								431131	373492	325981	287255	255026
0.3065	A										144.1	149.1	154.2
	B										8913	7578	6498
	C										2732	2323	1992
	D										393680	346319	307000

Wire Diameter: 0.0625-0.3065 in.
Mean Spring Diameter: 0.860-1.250 in.

Wire Dia. (in.)		Mean Diameter of Spring (in.)											
		1.3125	1.375	1.4375	1.500	1.562	1.625	1.687	1.750	1.875	2.000	2.125	2.250
0.1055	A	3174	3308	3443	3578								
	B	78.79	68.53	59.97	52.78								
	C	8.31	7.23	6.33	5.57								
	D	26380	23918	21786	19926								
0.1205	A	2163	2253	2344	2434	2524	2615	2705	2796	2977			
	B	134.1	116.6	102.1	89.83	79.55	70.66	63.15	56.57	45.99			
	C	16.2	14.1	12.3	10.8	9.59	8.51	7.61	6.82	5.54			
	D	34948	31665	28823	26347	24193	22263	20581	19060	16501			
0.125	A	1947	2027	2108	2189	2270	2351	2432	2514	2676	2838		
	B	155.3	135.0	118.2	104.0	92.03	81.82	73.06	65.51	53.26	43.88		
	C	19.4	16.9	14.8	13.0	11.5	10.2	9.13	8.19	6.66	5.49		
	D	37781	34225	31147	28446	26117	24047	22213	20581	17814	15569		
0.135	A	1561	1625	1689	1754	1817	1882	1946	2011	2139	2268	2397	
	B	211.2	183.7	160.8	141.5	125.3	111.3	99.48	89.12	72.46	59.70	49.78	
	C	28.5	24.8	21.7	19.1	16.9	15.0	13.4	12.0	9.78	8.06	6.72	
	D	44522	40312	36672	33503	30748	28282	26133	24192	20928	18283	16108	
0.1483	A	1194	1242	1291	1339	1387	1435	1484	1532	1629	1727	1824	1921
	B	307.6	267.6	234.2	206.1	182.5	162.1	144.9	129.8	105.5	86.94	72.48	61.06
	C	45.6	39.7	34.7	30.6	27.1	24.0	21.5	19.2	15.6	12.9	10.7	9.06
	D	54465	49284	44808	40915	37532	34507	31873	29493	25497	22261	19604	17395
0.162	A	928.8	965.7	1003	1040	1076	1114	1151	1188	1262	1337	1411	1486
	B	438.0	381.0	333.4	293.5	259.9	230.8	206.3	184.8	150.3	123.8	103.2	86.95
	C	71.0	61.7	54.0	47.5	42.1	37.4	33.4	29.9	24.3	20.1	16.7	14.1
	D	65913	59605	54160	49427	45319	41647	38452	35567	30727	26810	23597	20928
0.177	A	723.2	751.4	779.6	807.9	836.0	864.6	892.8	921.4	978.3	1035	1092	1149
	B	624.2	542.9	475.1	418.2	370.3	328.9	294.0	263.4	214.1	176.4	147.1	123.9
	C	110	96.1	84.1	74.0	65.6	58.2	52.0	46.6	37.9	31.2	26.0	21.9
	D	79904	72207	65568	59804	54804	50338	46455	42952	37078	32330	28438	25209
0.192	A	575.4	597.4	619.5	641.6	663.5	685.9	707.9	730.3	774.8	819.3	864.0	908.6
	B	864.3	751.7	657.9	579.0	512.8	455.4	407.0	364.6	296.5	244.3	203.7	171.6
	C	166	144	126	111	98.5	87.4	78.1	70.0	56.9	46.9	39.1	32.9
	D	95482	86222	78245	71323	65325	59972	55321	51126	44100	38428	33782	29930
0.207	A	466.3	483.8	501.3	518.9	536.4	554.2	571.7	589.5	625.0	660.5	696.0	731.6
	B	1168	1016	888.8	782.3	692.8	615.3	549.9	492.6	400.5	330.0	275.1	231.8
	C	242	210	184	162	143	127	114	102	82.9	68.3	57.0	48.0
	D	112709	101706	92236	84027	76919	70581	65076	60117	51815	45120	39641	35103
0.2253	A	368.5	382.0	395.6	409.1	422.6	436.4	449.9	463.7	491.1	518.6	546.1	573.7
	B	1639	1425	1247	1098	972.2	863.5	771.7	691.3	562.1	463.1	386.1	325.3
	C	369	321	281	247	219	195	174	156	127	104	87.0	73.3
	D	136061	122671	111160	101193	92571	84891	78226	72226	62194	54112	47508	42041
0.2437	A	296.8	307.4	318.0	328.7	339.3	350.1	360.8	371.6	393.2	414.9	436.6	458.3
	B	2243	1951	1707	1503	1331	1182	1056	946.4	769.4	634.0	528.8	445.3
	C	547	475	416	366	324	288	257	231	188	155	129	109
	D	162249	146150	132329	120375	110045	100851	92881	85711	73735	64101	56236	49733
0.2625	A	242.2	250.6	259.0	267.5	275.9	284.6	293.1	301.7	318.9	336.2	353.5	370.9
	B	3020	2626	2299	2023	1792	1591	1422	1274	1036	853.5	711.5	599.4
	C	793	689	603	531	470	418	373	334	272	224	187	157
	D	191953	172747	156280	142054	129774	118854	109397	100896	86714	75320	66029	58355
0.283	A	197.4	204.1	210.8	217.5	224.2	231.0	237.7	244.6	258.3	272.0	285.8	299.6
	B	4079	3548	3105	2733	2420	2150	1921	1721	1399	1153	961.2	809.8
	C	1154	1004	879	773	685	608	544	487	396	326	272	229
	D	227918	204904	185199	168199	153542	140522	129258	119142	102285	88762	77749	68662
0.3065	A	159.3	164.4	169.6	174.9	180.1	185.4	190.7	196.1	206.8	217.6	228.4	239.2
	B	5613	4882	4272	3760	3330	2957	2643	2368	1925	1586	1323	1114
	C	1720	1496	1309	1152	1021	906	810	726	590	486	405	341
	D	274001	246039	222138	201549	183822	168096	154506	142314	122026	105779	92567	81681
0.331	A	129.8	133.8	137.9	142.0	146.1	150.3	154.4	158.7	167.1	175.6	184.2	192.7
	B	7634	6640	5811	5114	4529	4023	3595	3221	2619	2158	1799	1515
	C	2527	2198	1923	1693	1499	1331	1190	1066	867	714	595	502
	D	327919	294076	265203	240372	219024	200111	183787	169159	144855	125426	109651	96670
0.3625	A	102.2	105.2	108.2	111.3	114.3	117.5	120.6	123.8	130.2	136.6	143.0	149.5
	B	10982	9552	8359	7357	6516	5787	5172	4633	3767	3104	2588	2180
	C	3981	3463	3030	2667	2362	2098	1875	1680	1366	1125	938	790
	D	406714	364119	327868	296761	270070	246466	226126	207926	177748	153679	134177	118158
0.3938	A		84.69	87.00	89.34	91.70	94.11	96.51	98.96	103.9	108.8	113.8	118.8
	B		13303	11642	10247	9074	8059	7203	6453	5246	4323	3604	3036
	C		5239	4585	4035	3574	3174	2837	2541	2066	1702	1419	1196
	D		443677	398877	360523	327681	298691	273752	251471	214600	185264	161544	142094
0.4375	A					69.55	71.25	72.97	74.70	78.21	81.77	85.37	88.99
	B					13811	12278	10963	9830	7992	6585	5490	4625
	C					6042	5371	4796	4301	3497	2881	2402	2023
	D					420258	382719	349985	321268	273483	235594	205050	180069

Wire Diameter: 0.1055-0.4375 in.
Mean Spring Diameter: 1.3125-2.250 in.

Wire Dia. (in.)		Mean Diameter of Spring (in.)											
		2.375	2.500	2.625	2.750	2.875	3.000	3.125	3.250	3.375	3.500	3.625	3.750
0.162	A	1560	1635	1709									
	B	73.93	63.39	54.76									
	C	12.0	10.3	8.87									
	D	18687	16788	15164									
0.177	A	1207	1264	1321	1378	1435	1492	1550	1607	1664			
	B	105.4	90.33	78.03	67.87	59.39	52.27	46.25	41.12	36.71			
	C	18.6	16.0	13.8	12.0	10.5	9.25	8.19	7.28	6.50			
	D	22499	20204	18242	16553	15088	13809	12686	11694	10814			
0.192	A	953.3	998.0	1043	1088	1132	1177	1222	1267	1312			
	B	145.9	125.1	108.0	93.96	82.23	72.38	64.03	56.93	50.83			
	C	28.0	24.0	20.7	18.0	15.8	13.9	12.3	10.9	9.76			
	D	26700	23966	21631	19621	17879	16358	15024	13846	12802			
0.207	A	767.2	802.9	838.6	874.3	910.0	945.7	981.5	1017	1053			
	B	197.1	169.0	146.0	127.0	111.1	97.79	86.51	76.91	68.68			
	C	40.8	35.0	30.2	26.3	23.0	20.2	17.9	15.9	14.2			
	D	31300	28083	25337	22975	20928	19143	17577	16195	14970			
0.2253	A	601.3	628.9	656.5	684.2	711.8	739.5	767.2	794.9	822.7	850.4	878.1	
	B	276.6	237.1	204.8	178.2	155.9	137.2	121.4	107.9	96.38	86.42	77.78	
	C	62.3	53.4	46.2	40.1	35.1	30.9	27.4	24.3	21.7	19.5	17.5	
	D	37466	33597	30298	27462	25006	22864	20987	19331	17864	16557	15389	
0.2437	A	480.1	501.9	523.7	545.5	567.3	589.2	611.1	632.9	654.8	676.7	698.6	720.5
	B	378.6	324.6	280.4	243.9	213.4	187.9	166.2	147.8	131.9	118.3	106.5	96.18
	C	92.3	79.1	68.3	59.4	52.0	45.8	40.5	36.0	32.2	28.8	25.9	23.4
	D	44295	39701	35785	32421	29510	26973	24750	22791	21055	19510	18129	16889
0.2625	A	388.2	405.7	423.1	440.5	458.0	475.5	492.9	510.4	527.9	545.4	562.9	580.5
	B	509.7	437.0	377.5	328.3	287.3	252.9	223.7	198.9	177.6	159.2	143.3	129.5
	C	134	115	99.1	86.2	75.4	66.4	58.7	52.2	46.6	41.8	37.6	34.0
	D	51943	46531	41922	37964	34541	31561	28950	26649	24613	22800	21181	19728
0.283	A	313.5	327.3	341.2	355.1	369.0	382.9	396.9	410.8	424.8	438.7	452.7	466.7
	B	688.5	590.3	509.9	443.5	388.1	341.6	302.2	268.7	239.9	215.1	193.6	174.9
	C	195	167	144	126	110	96.7	85.5	76.0	67.9	60.9	54.8	49.5
	D	61078	54683	49240	44571	40534	37022	33946	31239	28842	26711	24807	23100
0.3065	A	250.1	260.9	271.8	283.6	294.5	305.5	316.5	327.5	338.5	349.5	360.5	371.5
	B	947.3	812.2	701.6	607.8	531.9	468.2	414.2	368.2	328.8	294.8	265.4	239.7
	C	290	249	215	186	163	143	127	113	101	90.3	81.3	73.4
	D	72604	64958	58458	52774	47971	43794	40140	36923	34079	31550	29292	27268
0.331	A	201.3	209.9	218.6	227.2	235.9	244.5	253.2	261.9	270.6	279.3	288.0	296.7
	B	1288	1105	954.3	830.0	726.4	639.3	565.6	502.8	449.0	402.6	362.4	327.3
	C	426	366	316	275	240	212	187	166	149	133	120	108
	D	85860	76765	69039	62422	56711	51748	47409	43592	40218	37221	34546	32149
0.3625	A	156.0	162.6	169.1	175.7	182.2	188.8	195.4	202.0	208.6	215.2	221.9	228.5
	B	1854	1589	1373	1194	1045	919.7	813.7	723.3	645.9	579.1	521.3	470.9
	C	672	576	498	433	379	333	295	262	234	210	189	171
	D	104840	93648	84154	76032	69029	62950	57638	52971	48847	45186	41922	38998
0.3938	A	123.9	129.0	134.0	139.1	144.2	149.4	154.5	159.6	164.8	169.9	175.1	180.2
	B	2581	2213	1912	1663	1455	1281	1133	1007	899.6	806.6	726.0	655.8
	C	1017	872	753	655	573	504	446	397	354	318	286	258
	D	125950	112402	100925	91116	82668	75341	68945	63329	58371	53972	50052	46544
0.4375	A	92.63	96.30	99.98	103.7	107.4	111.1	114.8	118.5	122.3	126.0	129.8	133.5
	B	3933	3372	2913	2533	2217	1951	1726	1535	1370	1229	1106	999.0
	C	1721	1475	1274	1108	970	854	755	671	600	538	484	437
	D	159380	142053	127401	114899	104147	94834	86714	79592	73312	67745	62788	58355
0.500	A	64.32	66.74	69.18	71.62	74.08	76.55	79.02	81.50	83.99	86.48	88.97	91.47
	B	6709	5752	4969	4322	3782	3329	2945	2618	2338	2096	1887	1704
	C	3354	2876	2484	2161	1891	1664	1473	1309	1169	1048	943	852
	D	215770	191953	171864	154763	140088	127401	116359	106690	98175	90638	83936	77947
0.5625	A	46.84	48.51	50.19	51.88	53.59	55.30	57.02	58.75	60.48	62.22	63.96	65.70
	B	10746	9214	7959	6922	6058	5532	4717	4194	3745	3358	3022	2730
	C	6045	5183	4477	3894	3408	2999	2654	2359	2106	1889	1700	1536
	D	283137	251397	224698	202026	182613	165862	151310	138587	127401	117514	108732	100896
0.625	A	35.42	36.60	37.81	39.02	40.24	41.48	42.72	43.96	45.21	46.47	47.73	48.99
	B	16379	14043	12131	10551	9233	8127	7190	6392	5708	5118	4606	4161
	C	10237	8777	7582	6594	5771	5079	4494	3995	3567	3199	2879	2601
	D	362556	321268	286636	257304	232244	210665	191953	175622	161284	148629	137404	127401
0.6875	A		28.48	29.36	30.25	31.15	32.06	32.98	33.91	34.84	35.77	36.71	37.65
	B		20560	17761	15447	13519	11898	10527	9358	8357	7493	6744	6092
	C		14135	12211	10620	9294	8180	7237	6434	5745	5151	4637	4188
	D		402541	358484	321268	289548	262293	238704	218151	200137	184260	170195	157678
0.750	A						25.42	26.11	26.82	27.52	28.23	28.93	29.66
	B						16852	14909	13254	11835	10612	9552	8628
	C						12639	11182	9941	8877	7959	7164	6471
	D						321268	292008	266562	244294	224698	207362	191953

Wire Diameter. 0.162-0.750 in.

Mean Spring Diameter: 2.375-3.750 in.

Wire Dia. (in.)		Mean Diameter of Spring (in.)											
		3.875	4.000	4.125	4.250	4.375	4.500	4.625	4.750	4.875	5.000	5.250	5.500
0.2437	A	742.5	764.4										
	B	87.17	79.25										
	C	21.2	19.3										
	D	15772	14763										
0.2625	A	598.0	615.5										
	B	117.3	106.7										
	C	30.8	28.0										
	D	18420	17237										
0.283	A	480.6	494.6	508.6	522.6	536.6	550.6						
	B	158.5	144.1	131.4	120.2	110.1	101.2						
	C	44.9	40.8	37.2	34.0	31.2	28.6						
	D	21562	20174	18915	17770	16726	15772						
0.3065	A	382.5	393.6	403.4	414.4	425.5	436.5	447.5	458.5	469.5	480.5		
	B	217.3	197.5	180.8	165.3	151.5	139.3	128.3	118.4	109.5	101.5		
	C	66.5	60.5	55.4	50.7	46.4	42.7	39.3	36.3	33.6	31.1		
	D	25447	23802	22358	21090	19962	18930	17983	17110	16310	15573		
0.331	A	305.5	314.2	322.9	331.6	340.4	349.1	357.8	366.6	375.3	384.1		
	B	296.7	269.7	245.9	224.9	206.1	189.4	174.5	161.1	149.0	138.1		
	C	98.2	89.3	81.4	74.4	68.2	62.7	57.8	53.3	49.3	45.7		
	D	29994	28047	26284	24682	23222	21888	20665	19542	18508	17554		
0.3625	A	235.1	241.7	248.4	255.0	261.6	268.3	274.9	281.6	288.2	294.9	308.2	321.5
	B	426.8	388.0	353.8	323.5	296.5	272.5	251.0	231.7	214.3	198.6	171.6	149.2
	C	155	141	128	117	107	98.8	91.0	84.0	77.7	72.0	62.2	54.1
	D	36370	33998	31851	29901	28124	26501	25014	23649	22393	21234	19171	17394
0.3938	A	185.4	190.5	195.7	200.9	206.1	211.2	216.4	221.6	226.8	232.0	242.3	252.7
	B	594.4	540.4	492.7	450.5	413.0	379.5	349.6	322.7	298.5	276.7	239.0	207.9
	C	234	213	194	177	163	149	138	127	118	109	94.1	81.9
	D	43391	40548	37975	35639	33512	31569	29791	28158	26657	25272	22807	20685
0.4375	A	137.3	141.0	144.8	148.5	152.3	156.1	159.8	163.6	167.4	171.2	178.7	186.3
	B	905.4	823.2	750.6	686.3	629.1	578.1	532.5	491.6	454.7	421.5	364.1	316.7
	C	396	360	328	300	275	253	233	215	199	184	159	139
	D	54375	50787	47544	44600	41922	39477	37240	35188	33301	31561	28468	25805
0.500	A	93.98	96.48	98.99	101.5	104.0	106.5	109.0	111.6	114.1	116.6	121.7	126.7
	B	1545	1404	1280	1171	1073	986.3	908.5	838.6	775.7	719.0	621.1	540.2
	C	772	702	640	585	537	493	454	419	388	360	311	270
	D	72579	67745	63377	59418	55818	52535	49533	46781	44252	41922	37781	34225
0.5625	A	67.45	69.20	70.96	72.71	74.47	76.23	77.99	79.76	81.52	83.29	86.83	90.37
	B	2474	2249	2051	1875	1719	1580	1455	1343	1243	1152	994.9	865.3
	C	1392	1265	1154	1055	967	889	819	756	699	648	560	487
	D	93877	87564	81866	76705	72017	67745	63841	60265	56981	53958	48589	43983
0.625	A	50.26	51.53	52.80	54.07	55.35	56.62	57.90	59.18	60.47	61.75	64.32	66.89
	B	3771	3428	3126	2858	2620	2408	2218	2047	1894	1755	1516	1319
	C	2357	2143	1954	1786	1638	1505	1386	1280	1184	1097	948	824
	D	118450	110408	103156	96594	90638	85216	80264	75732	71572	67745	60956	55137
0.6875	A	38.59	39.54	40.49	41.44	42.39	43.35	44.30	45.26	46.22	47.18	49.10	51.03
	B	5521	5020	4577	4185	3836	3525	3247	2998	2773	2570	2220	1931
	C	3796	3451	3147	2877	2637	2424	2232	2061	1906	1767	1528	1327
	D	146489	136447	127401	119224	111808	105061	98906	93275	88111	83364	74949	67745
0.750	A	30.38	31.11	31.83	32.56	33.29	34.02	34.75	35.49	36.22	36.96	38.43	39.91
	B	7820	7109	6482	5927	5433	4993	4599	4245	3927	3640	3144	2735
	C	5865	5332	4862	4445	4075	3745	3449	3184	2945	2730	2358	2051
	D	178196	165862	154763	144740	135657	127401	119875	112995	106690	100896	90638	81866
0.8125	A		24.99	25.56	26.13	26.70	27.27	27.84	28.41	28.99	29.56	30.72	31.88
	B		9792	8929	8164	7484	6877	6335	5848	5409	5014	4331	3767
	C		7956	7254	6633	6081	5588	5147	4751	4395	4073	3519	3060
	D		198844	185413	173295	162324	152360	143284	134994	127401	120430	108097	97562
0.875	A		20.44	20.89	21.34	21.79	22.25	22.70	23.16	23.62	24.07	24.99	25.92
	B		13171	12009	10981	10066	9250	8520	7865	7276	6743	5825	5066
	C		11524	10508	9608	8808	8094	7455	6882	6366	5901	5097	4433
	D		235594	219530	205050	191953	180069	169252	159380	150344	142054	127401	114899
0.9375	A		16.98	17.34	17.70	18.07	18.43	18.80	19.17	19.54	19.91	20.65	21.40
	B		17357	15826	14470	13265	12190	11228	10365	9588	8887	7677	6677
	C		16272	14837	13566	12436	11428	10526	9717	8989	8331	7197	6259
	D		276327	257304	240176	224698	210665	197904	186266	175622	165862	148629	133943
1.000	A		14.30	14.59	14.89	15.18	15.48	15.78	16.08	16.38	16.69	17.29	17.91
	B		22469	20487	18732	17172	15781	14535	13418	12412	11504	9938	8643
	C		22469	20487	18732	17172	15781	14535	13418	12412	11504	9938	8643
	D		321268	298938	278851	260719	244294	229370	215770	203341	191953	171864	154763
1.0625	A										14.15	14.65	15.16
	B										14661	12665	11015
	C										15577	13456	11703
	D										220429	197190	177433

Wire Diameter. 0.2437-1.0625 in.

Mean Spring Diameter: 3.875-5.500 in.

Wire Dia. (in.)		Mean Diameter of Spring (in.)											
		5.750	6.000	6.500	7.000	7.500	8.000	8.500	9.000	9.500	10.000	10.500	11.000
0.3625	A	334.8											
	B	130.6											
	C	47.3											
	D	15853											
0.3938	A	263.1	273.5	294.2									
	B	181.9	160.1	125.9									
	C	71.6	63.0	49.6									
	D	18846	17242	14592									
0.4375	A	193.8	201.4	216.5	231.7	246.8	262.0	277.2	292.4				
	B	277.1	243.9	191.8	153.6	124.9	102.9	85.79	72.27				
	C	121	107	83.9	67.2	54.6	45.0	37.5	31.6				
	D	23500	21491	18174	15569	13486	11795	10403	9243				
0.500	A	131.8	136.8	147.0	157.1	167.2	177.4	187.5	197.7	207.9	218.0	228.2	238.4
	B	472.8	416.1	327.3	262.0	213.0	175.5	146.3	123.3	104.8	89.88	77.64	67.52
	C	236	208	164	131	107	87.8	73.2	61.6	52.4	44.9	38.8	33.8
	D	31147	28466	24047	20581	17814	15569	13723	12187	10895	9797	8858	8047
0.5625	A	93.91	97.45	104.6	111.7	118.8	125.9	133.0	140.2	147.3	154.4	161.6	168.7
	B	757.3	666.5	524.2	419.7	341.2	281.2	234.4	197.5	167.9	144.0	124.4	108.2
	C	426	375	295	236	192	158	132	111	94.4	81.0	70.0	60.8
	D	40002	36537	30831	26364	22800	19913	17541	15569	13911	12505	11301	10264
0.625	A	69.47	72.05	77.22	82.39	87.57	92.76	97.94	103.1	108.3	113.5	118.7	123.9
	B	1154	1016	799.0	639.7	520.1	428.6	357.3	301.0	255.9	219.4	189.5	164.9
	C	721	635	499	400	325	268	223	188	160	137	118	103
	D	50113	45745	38559	32941	28466	24844	21872	19402	17328	15569	14065	12769
0.6875	A	52.96	54.90	58.77	62.65	66.54	70.43	74.32	78.22	82.12	86.02	89.92	93.82
	B	1690	1487	1170	936.6	761.5	627.5	523.1	440.7	374.7	321.3	277.5	241.4
	C	1162	1023	804	644	524	431	360	303	258	221	191	166
	D	61530	56132	47264	40341	34833	30380	26728	23697	21153	18998	17156	15569
0.750	A	41.40	42.88	45.86	48.84	51.83	54.82	57.81	60.81	63.81	66.82	69.82	72.82
	B	2393	2106	1657	1327	1079	888.7	740.9	624.1	530.7	455.0	393.0	341.8
	C	1795	1580	1243	995	809	666	556	468	398	341	295	256
	D	74306	67745	56981	48589	41922	36537	32125	28466	25398	22800	20581	18671
0.8125	A	33.04	34.20	36.54	38.88	41.22	43.57	45.93	48.28	50.64	53.00	55.36	57.72
	B	3296	2901	2282	1827	1485	1224	1020	859.7	730.9	626.7	541.4	470.8
	C	2678	2357	1854	1485	1207	995	829	698	594	509	440	383
	D	88493	80630	67745	57715	49755	43333	38078	33722	30073	26985	24349	22081
0.875	A	26.84	27.77	29.64	31.50	33.38	35.26	37.14	39.02	40.90	42.79	44.68	46.57
	B	4434	3902	3069	2458	1998	1646	1373	1156	983.2	842.9	728.2	633.3
	C	3880	3415	2686	2150	1748	1441	1201	1012	860	738	637	554
	D	104147	94834	79592	67745	58355	50787	44600	39477	35188	31561	28466	25805
0.9375	A	22.15	22.90	24.41	25.92	27.44	28.97	30.49	32.02	33.55	35.08	36.62	38.15
	B	5843	5143	4045	3239	2633	2170	1809	1524	1296	1111	959.6	834.6
	C	5478	4821	3792	3036	2468	2034	1696	1429	1215	1041	900	782
	D	121326	110408	92561	78709	67745	58918	51709	45744	40754	36537	32941	29851
1.000	A	18.52	19.14	20.38	21.62	22.87	24.12	25.38	26.63	27.89	29.15	30.41	31.68
	B	7564	6657	5236	4192	3409	2809	2342	1973	1677	1438	1242	1080
	C	7564	6657	5236	4192	3409	2809	2342	1973	1677	1438	1242	1080
	D	140088	127401	106690	90638	77949	67745	59418	52535	46781	41922	37781	34225
1.0625	A	15.67	16.18	17.21	18.24	19.28	20.32	21.37	22.41	23.46	24.51	25.56	26.61
	B	9640	8484	6673	5343	4344	3579	2984	2514	2137	1833	1583	1377
	C	10242	9015	7090	5677	4616	3803	3171	2671	2271	1947	1682	1463
	D	160496	145868	122018	103562	88991	77287	67745	59864	53281	47726	42995	38933
1.125	A		13.83	14.69	15.55	16.43	17.30	18.18	19.06	19.94	20.82	21.71	22.59
	B		10664	8387	6715	5460	4499	3751	3160	2687	2308	1990	1731
	C		11997	9436	7555	6142	5061	4220	3555	3022	2591	2238	1947
	D		165862	138587	117514	100896	87564	76705	67745	60265	53958	48589	43983
1.1875	A		11.92	12.65	13.39	14.12	14.87	15.61	16.36	17.10	17.85	18.60	19.36
	B		13239	10412	8337	6778	5585	4656	3923	3335	2860	2470	2148
	C		15721	12365	9900	8049	6632	5529	4658	3961	3396	2933	2551
	D		187442	156441	132525	113691	98597	86316	76191	67745	60627	54574	49382
1.250	A			10.99	11.62	12.25	12.88	13.52	14.16	14.80	15.44	16.08	16.72
	B			12784	10235	8322	6857	5717	4816	4095	3511	3083	2638
	C			15980	12794	10402	8571	7146	6020	5118	4388	3791	3297
	D			175622	148629	127401	110408	96594	85216	75732	67745	60956	55137
1.375	A				8.942	9.412	9.885	10.36	10.84	11.32	11.80	12.28	12.76
	B				14986	12184	10039	8370	7051	5995	5140	4440	3862
	C				20605	16753	13804	11508	9695	8243	7068	6105	5310
	D				184260	157678	136447	119224	105061	93275	83363	74949	67745
1.500	A							8.140	8.505	8.872	9.240	9.609	9.979
	B							11854	9986	8491	7280	6289	5469
	C							17781	14979	12736	10920	9433	8204
	D							144740	127401	112995	100896	90638	81866

Wire Diameter: 0.3625-1.500 in.
Mean Spring Diameter: 5.750-11.000 in.

DESIGN ABSTRACTS

Selecting Cermets

for high-temperature applications

By J. T. Norton

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Cambridge, Mass.

A cermet may be defined as an aggregate or composite of a hard and refractory component intimately combined with a lower-melting metallic component to form a dense and compact body. Such bodies are made by the methods of powder metallurgy; that is, an intimate mixing of the powdered components, a pressing to shape, and a sintering operation at a temperature near the melting point of the metal component to form a dense, pore-free body.

The class of cermets which leads on the basis of practical performance is that of the metal-bonded titanium carbides. Alloys of this class are being developed and produced by several organizations using somewhat different compositions and fabricating techniques. The compositions to be described have been chosen because they are typical and more particularly because a consistent set of data as to their properties is available.

Titanium Carbide: Titanium carbide, with the chemical formula TiC, is a hard and refractory crystalline substance with a melting point of 3250 C (5880 F). It has a bright gray metallic appearance and is a good electrical conductor. In fact it corresponds to all of the usual criteria of a metallic substance except that it is very brittle.

Fabrication of Carbide Parts: Manufacturing procedures used for titanium carbides are typical of those used for other cermets. The purified titanium-carbide powder is mixed with the desired proportion of the binder metal, also in powder form, and the mixture is ground and intimately mixed in a ball mill for periods of 2 to 4 days. Control of the carbide-particle size and size distribution is important. After grinding, the powder is carefully dried, a small amount of lubricant is added and the powder is pressed.

If the parts are relatively simple in form and are to be made in sufficient quantity to justify die costs, they may be pressed in a die to final shape, due allowance being made for shrinkage in the final sintering operation. Otherwise, blanks may be pressed and then given a preliminary sintering operation. In this condition, the compacts are sufficiently strong to handle but may easily be machined to the final shape.

In either case the final operation is a sintering treatment in vacuum at a temperature usually just above the melting point of the binder metal. In this operation the body shrinks, becoming dense and free from pores. After final sintering the material is very hard and, except for composition with very high binder content, cannot be machined. However, if all steps of the process are carefully controlled, the shrinkage during sintering can be predicted accurately and ex-

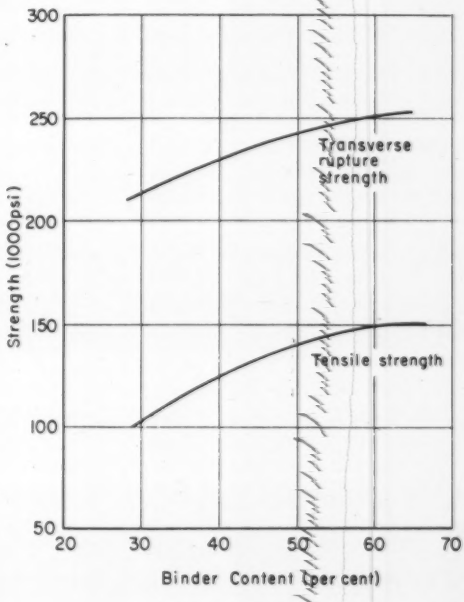


Fig. 1 — How binder-metal content affects transverse rupture strength and tensile strength of titanium-carbide cermets at room temperature

cellent dimensional tolerances can be maintained.

If final finishing is required, it is done by grinding, usually with diamond wheels. An excellent surface finish can be obtained.

The structure of the finally sintered body is one of carbide particles embedded in a matrix of the binder metal.

Several important variations of the conventional procedures are possible. Instead of pressing in a die, the blanks may be pressed hydrostatically in order to obtain a more uniform density distribution. Hot pressing in graphite dies may be used to combine pressing and sintering into a single step. By mixing suitable plasticizers with the powder, shapes may be extruded to produce tubes, rods or formed sections, and then sintered. If properly carried out, the properties of the final body are essentially the same for these different procedures.

Still another method is to prepare a pressing of the carbide alone with the desired porosity and place it in the sintering furnace in contact with a block of the binder metal of sufficient volume to fill the pores. When the metal melts, it infiltrates the carbide body completely and the whole shrinks to full density. Particular circumstances determine which of these procedures is the most practical.

Properties of TiC Cermets: To illustrate typical properties, three grades of metal-bonded titanium carbide were prepared under identical conditions with the binder metal, which is an alloy of nickel-cobalt-chromium, in the proportions of 3 parts nickel, 1 part cobalt, and 1 part chromium. Grade B40 contains 40 per cent by weight of the binder metal, C50 has 50 per cent and D65 has 65 per cent. These correspond to 29, 37, and 52 per cent by volume of the metal phase.

In cermet development work, strengths are frequently measured by means of a bend test because it is a straightforward test requiring a simple specimen. Strength values, however, are dependent upon the test conditions. Tensile tests, on the other hand are more significant for purposes of design, but it is very time-consuming and expensive to prepare accurate tensile specimens and to provide testing conditions of very precise axial loading. Fortunately, for the grades to be considered, both sets of data are available and Fig. 1 shows how they are related at room temperature. Bend-strength values (modulus of rupture) are higher by a factor varying from about 2.0 at low binder contents to about 1.7 at the high binder contents. It is of interest to note that the strength increases with increasing binder content over the range investigated. The curves appear to approach a maximum and would undoubtedly fall at still higher binder contents.

This may seem strange in view of the hardness values which decrease with increasing binder content, the values for grade B40 being 960 DPH; C50 being 820 DPH and D65 being 600 DPH. This behavior, however, appears to be characteristic of these rather brittle materials. Impact strength on the other hand increases markedly with binder content, the values, as measured by a Charpy test on an unnotched bar of 1 sq cm cross section for grades B40, C50 and D65 being 46, 70 and 106 in.-lb, respectively.

The influence of temperature on tensile strength is revealed in Fig. 2, where the results of short-time tensile tests are shown. It will be observed that grade D65 which is the strongest at room temperature loses its strength more rapidly and at 1000 C (1830 F) it has become the weakest, the order of strengths being just reversed as compared with room temperatures. This is a reflection of the loss of strength of the binder metal itself. Grade D65 has lost half its strength at 800 C (1470 F) while grade B40 still has half of its original strength at 900 C (1650 F).

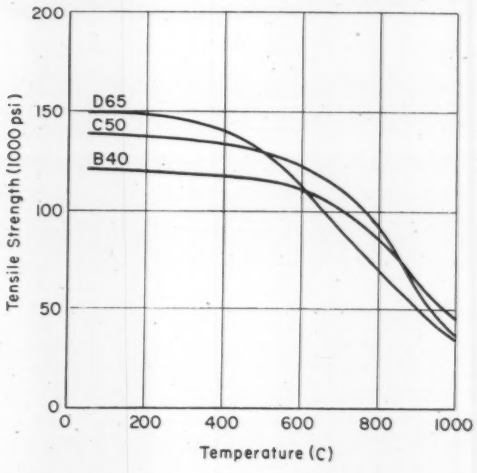


Fig. 2—Effect of temperature on tensile strength of TiC cermets B40, C50 and D65 containing 40, 50 and 65 per cent by weight of binder metal, respectively

The long-time strength at elevated temperature is, in many respects, a much more useful index of the suitability of these materials. Such a test carried out in air reveals the stability of the alloy and the possible loss of strength due to oxidation. Since in a long-time test most of the compositions fail by fracture without very much elongation, the stress-rupture test rather than the conventional creep test is usually employed. This test gives the stress at which the material will fracture in tension after a definite period of time at a specific temperature. This strength decreases with increasing time and the decrease, as would be expected, is more rapid at higher temperatures. Fig. 3 shows the behavior of grade C50 at 800 and 1000 C (1470 and 1830 F). For general purposes of comparison, the

strength for 100-hr life is a convenient figure.

Curves of the 100-hr life for the three grades considered in the temperature range from 800 to 1000 C (1470 to 1830 F) are shown in Fig. 4. The strength decreases with increasing temperature, and grade B40 with the lowest binder content is the strongest of the three, while grade D65 is the weakest. If one arbitrarily selects the operating temperature of 950 C (1740 F), these tests show permissible strength levels of approximately 25,000, 19,000, and 15,000 psi for grades B40, C50, and D65, respectively, for 100-hr lifetime. Thus, the short-time strength is higher by a factor of between 2 and 3 than the 100-hr strength. On the same figure are shown corresponding typical values for two of the so-called "superalloys." At any particular temperature within this range, the TiC cermets provide a significant increase in strength over the conventional high-temperature alloys.

The cermets appear to even better advantage with respect to the superalloys if the specific-gravity factor is considered. Values for the cermet grades B40, C50 and D65 are 6.25, 6.55, and 6.95 gm per sq cm, respectively, while that of the X40 alloy is 8.60 gm per sq cm. In applications where centrifugal loading is predominant or where strict weight limitations are important, the lower specific gravity of the cermets would work in their favor.

Two other properties of cermets should be taken into account. One is the elastic modulus, which is considerably higher for the TiC composition than for steels. Over the range of binder contents considered, Young's modulus varies from 46×10^6 to 56×10^6 psi. The other property is heat-shock resistance. It is difficult to be very specific about the real heat-shock resistance of cermets because the results depend so much upon the details of the test and form of the test specimen. The three cermet grades described here have passed the test of alternate heating and cooling set up by NACA, in a completely satisfactory manner. It is not possible to indicate the relative merits of the individual grades but all three appear to have adequate resistance for any contemplated application.

To summarize, metal-bonded titanium-carbide cermets possess an oxidation resistance and an elevated - temperature strength sufficient to raise the operating temperature approximately 100C above the limit set by the conventional high-temperature alloys. This improvement is offset by a lower impact strength which is inferior to the conventional alloys but probably adequate for many applications. Within the composition range of the cermets themselves, the high-temperature strength can be increased by varying the metal-binder content, but again a significant loss in impact strength is the price which must be paid. Proper selection is thus a compromise which depends upon the service conditions which must be met.

Other Carbide - Base Cermets: Among the other carbide-base materials are the tungsten-carbide base compositions well known as cutting tools and rock drills. These are cermets according to the definition given in the foregoing, but of course were very highly developed before the word cermet was invented. They are of interest for certain structural applications because of their high strength and hardness combined with a considerable toughness. They do not, however have sufficient resistance to oxidation to permit their use at high temperatures.

Some interesting cermets based upon chromium carbide have been developed in the last few years. This material has exceptional oxidation resistance but so far does not have the combination of high-temperature strength and impact resistance which permits it to compete with the TiC-base compositions in high-temperature application. Its hardness, corrosion resistance and thermal expansion have led to its consideration for use as precision gage blocks, wear-resistant guides and valve parts.

Boride-Base Cermets: The borides of the transition metals, like the carbides, are hard and refractory substances and have been extensively studied as components for cermets. Two borides of particular interest are those of zirconium and chromium which are being developed under the commercial designation of "Borolites." While zirconium-boride cermets are not as strong as the TiC cermets at room temperature, they retain a significant strength above 1100 C (2000 F). At this temperature, oxidation resistance is adequate for a life of at least 200 hr. Heat-shock resistance is sufficient

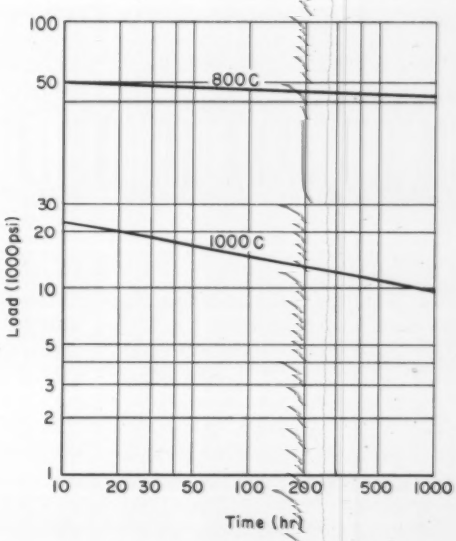


Fig. 3—Effect of time on strength of TiC cermet with 50 per cent by weight of binder at 800 and 1000 C

to pass the NACA test, but resistance to mechanical shock is disappointing. The zirconium-boride compositions have a very unusual resistance to attack by molten metals, and they are finding applications for parts of die-casting machines, bearings immersed in molten metal, thermocouple protection tubes and metal spray nozzles. Their relatively high electrical conductivity has also suggested their use as electrical contact materials. They have high hardness and can be given a very excellent surface finish.

Chromium-boride compositions have the same ability to retain strength at high temperature and have somewhat better oxidation, mechanical and heat-shock resistance than the zirconium-boride grades. Chromium boride has excellent resistance to chemical attack. The boride cermets have shown very good results in applications involving rather short-time cycles at very high temperatures.

Oxide-Base Cermets: Probably the first cermets investigated were those based on the metallic oxides such as BeO, Al_2O_3, Cr_2O_3, MgO, SiO_2, with various metallic binders. The group using alumina bonded with chromium or chromium-base alloys has shown the greatest promise. A composition containing about 70 per cent by weight of chromium (about 50 per cent by volume) has been made commercially under the name Haynes Metal Ceramic LT-1 and has found application as crucibles, thermocouple protection tubes and radiant heater tubes. It has excellent oxidation resistance up to 1200 C (2200 F) and is reasonably resistant to heat shock, but its tensile strength is only about half of that of the TiC cermets at room temperature and at 1000 C (1830 F). Similar compositions with a chromium-binder content of 30 per cent by weight have also been studied and show improved strength and creep-rupture properties in the 1000 to 1200 C (1930 to 2200 F) range where TiC-base materials are not usable. The compositions suffer, however, in thermal and mechanical shock resistance as the binder content is lowered.

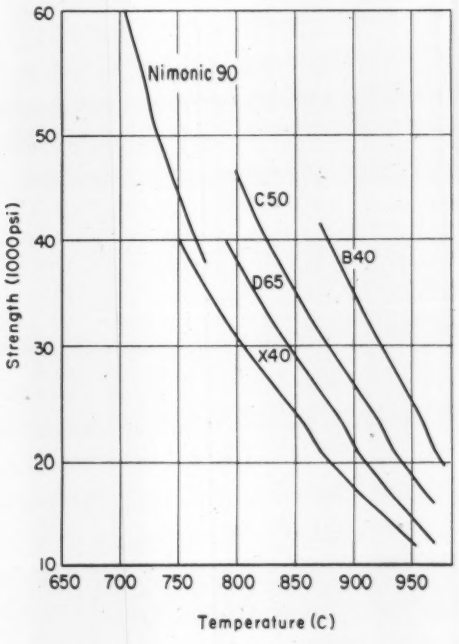


Fig. 4 — Strength in 100-hour stress-rupture test at different temperatures for three TiC cermets and two "superalloys"

Intermetallics: Cermets based on other refractory substances have been studied and the principal ones are the strong and high-melting intermetallic compounds such as the aluminides, silicides, titanides, etc. Compositions based on nickel aluminide (NiAl) have considerable merit. Their oxidation resistance is superior to the TiC-base composition at the higher temperatures. Their stress-rupture properties are comparable, and impact resistance is also of the same order, which is far ahead of the other noncarbide cermets. They also have shown unusual resistance to attack by molten glass.

Molybdenum disilicide ($MoSi_2$) also has a very high oxidation resistance but has not as yet shown sufficient strength for general application. Its electrical properties have led to its consideration as a high-temperature heating element.

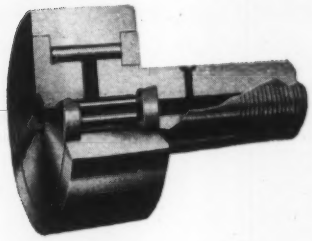
A number of the titanides, of which chromium titanide (Cr_2Ti) is an example, have shown very good stress-rupture properties at temperatures considerably above the limits of the TiC base materials, but as presently prepared they are all too brittle for practical consideration.

General Discussion: The overall picture of the present status in the cermet field, so far as structural parts for high temperatures are concerned, may be stated somewhat as follows: In the temperature range of 1600 to 1650 F, alloys are available which are quite adequate in strength and toughness; namely, the conventional superalloys. In the 1750 to 1800 F range, alloys with good strength properties and a toughness adequate for many applications are to be found in the metal-bonded titanium carbides. In the 1800 to 2200 F range, there are a number of cermet materials of adequate strength in short-time application, and a few with adequate long-time strength. However these are, without exception, too brittle to meet even the minimum specifications which a designer would set for a practical operating device.

The cermets are aggregate structures of a hard phase which is strong but brittle in bulk form, and a plastic metallic phase which is relatively weaker but more ductile in bulk. When intimately associated, the very small hard particles are surrounded by the

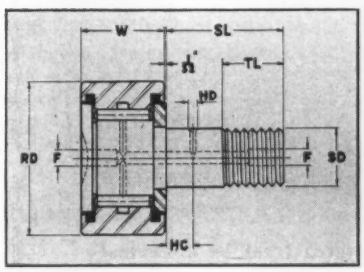
BEARING TIPS by McGill

BEARING BUILT FOR HEAVY-DUTY CAM LOADS



Camrol CF Bearings provide the ultimate in radial capacity, shock resistance and space economy for all cam actioned or guide and support roller applications. An extra heavy outer ring operates on a full complement of small diameter rollers supported by an integral inner race, roller retaining flange and stud. Designed as precision replacement for plain bearing or improvised bolt and bearing units.

New Sealed Bearing Adds to Versatility of Standard Cam Follower

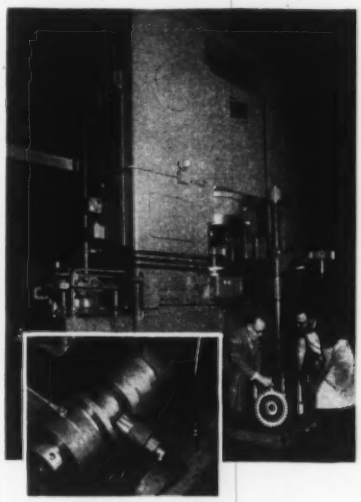


The new SCF series bearing keeps contamination out and lubrication in by means of specially-treated synthetic seals. The SCF bearing is interchangeable dimensionally with standard Camrol bearings.

140 Pages of Bearing Facts

Write for your copy of Catalog No. 52, a revised 140-page Bearing Selection Guide. It contains vital product information and 30 pages of engineering data.

CAMROL CF Bearings Cut Power Requirements on J. L. Ferguson Co. Packaging Machines



New Shear-Speed Shapers Achieve Greater Speed and Accuracy Using CAMROL CF Bearings

Michigan Tool Co. uses Camrol CF and CYR bearings in their new machines that produce gears up to 20 inches in diameter and up to 6-inch face widths in only 13 minutes. These bearings, acting as cam followers, accurately control cutting tool feed and relieve tools from the work on return strokes. They insure dependable, precision performance for automatic operation at high production speeds.

Up to 50 Camrol Bearings Used Per Machine

Used as load-carrying cam followers and as guide rollers in PACKOMATIC packaging machinery, McGill Camrol CF bearings have brought several desirable advantages to J. L. Ferguson Company in the eight years this firm has relied on Camrol Bearings.

Exceeding the performance of the roller and pin assembly formerly assembled in the Ferguson plant, the Camrol cam follower bearing has helped improve a variety of cam actuated operations on many of the versatile packaging machines built by Ferguson.

The Camrol CF bearings eliminate wear by reducing friction. This also reduces power requirements for the machines. The CF bearings cost less and are more easily applied than the previous assembly.

For trouble-free operation, up to 50 bearings per machine are now used by this company.

Insure performance with McGILL®

MULTIROL® GUIDEROL® CAMROL®
Full Type Roller Bearings

McGILL MANUFACTURING COMPANY, INC., 200 N. LAFAYETTE ST., VALPARAISO, INDIANA

—ITEM 629—

metal phase in the form of thin films. When a load is applied and the metal phase starts to deform, the yield strength of these thin films is raised very considerably by the restraint of the neighboring hard particles, and this is responsible for the high strengths observed. At the same time, the yielding of the metal phase produces a very complex stress distribution so that in general the hard particles are carrying far more than their share of the load. Under these circumstances they may actually fracture. Because of the metal films around the hard particles, the fracture path is not continuous and crack propagation is severely limited. Thus the metal phase makes its contribution to the toughness.

From a paper entitled "The Development of Cermets as Structural Materials" presented at the ASME Annual Meeting in Chicago, November, 1955.

Economies possible in

Preforming and Welding

By Harris P. Moyer

Manager, Aeronautical Div.
A. O. Smith Corp.
Milwaukee

OPTIMUM utilization of materials is realized when design and processes yield a maximum finished-part to blank-weight ratio and allow the excess metal to be removed at lowest cost. It is highly desirable to position the metal blank by a reliable process to provide optimum metal distribution with a minimum of chip making. Five processes capable of yielding such results are:

1. Precision forging
2. Contour rolling
3. Flash welding
4. Fusion welding
5. Precision heat treatment

In illustrating these processes a propeller blade may be used as an example because of the scope of processing involved and the fatigue stresses to which the item is subjected. In an item of this nature, it is absolutely necessary to provide reinforcement in all of the welded areas to guarantee no failure under service conditions. The propeller blade typifies the variety of operations that may be utilized in this type of fabrication. In the processing of the propeller blade described here the raw material utilization was approximately 60 per cent. This means that for every 100 pounds of material brought into the plant to produce blades, 60 pounds were theoretically capable of being shipped out.

A completed propeller blade approximately 19½ feet in diameter and roughly 18 inches wide is illustrated in *Fig.* 1. This particular blade is fabricated from 16 individual components, incorporating 14 flash welds and one fusion weld.

A breakdown of the individual detail parts and the major subassemblies prior to being joined by lateral flash welds is shown in *Fig.* 2.

The sequence of operations involved in producing typical edge section is shown in *Fig.* 3. Processing starts with a round bar with two subsequent preforges, a splash forge, a coin roll and two folding operations to produce the edge. *Fig.* 4 shows the cross sections of these edge sections.

Fig. 1—Propeller blade fabricated from 16 individual components

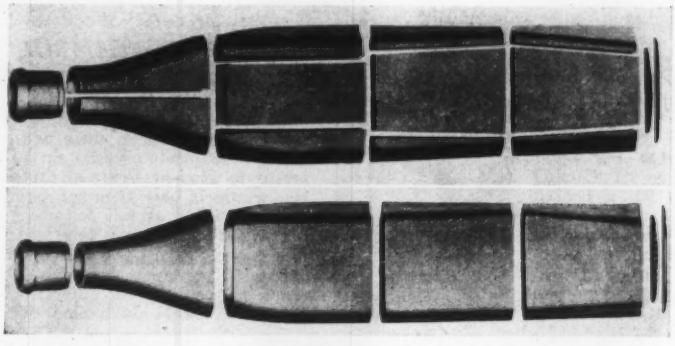


Fig. 2—Individual detail parts, top, and major subassemblies, bottom, prior to being joined by lateral flash welds

HOWELL MOTOR BRIEFS

Quick facts for those who apply and specify electric motors

New Stator Design is a Motor Life Saver!

One sure way to save years of motor life is to provide a better means of removing excess internal heat. That's what has been accomplished by the new stator lamination design developed for the Howell Series 100 motors.

Instead of the conventional smooth outer surface, this stator has wide ventilation slots in its circumference. With the dividing "fins" fitted against the motor frame, air passages are created that put 50% more stator heat transfer surface in direct contact with the flow of fan-driven air.

Copper-clad rotors shed heat faster, too

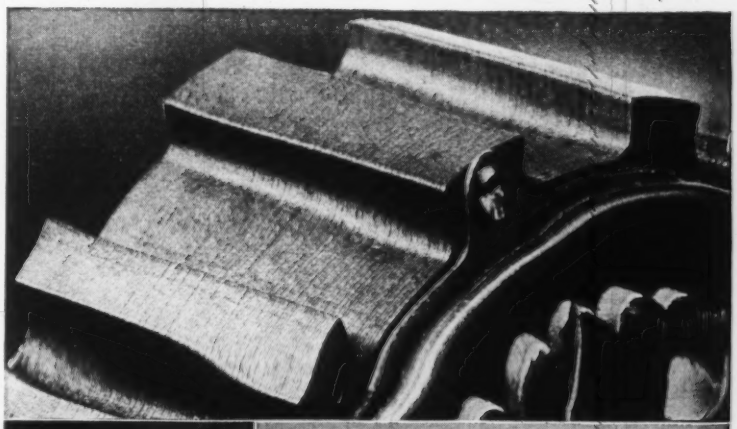
Rotor slot bars and end discs are a bonus feature of all Howell motors. Note below right the much greater thermal conductivity of copper, as compared to aluminum, the metal in common use for cast rotors today.

Significantly better heat dissipation is one of the reasons why Howell engineers, in designing for the new frame sizes, came up with such an outstanding group of motors in the new Series 100. They are not only smaller and lighter, they're cooler running than their horsepower equivalents in the old frame sizes.

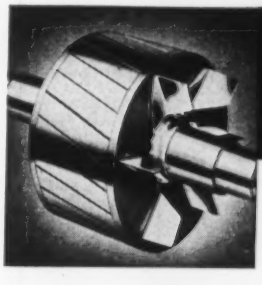
Why not go modern in motors?

Fact is, you really can't afford to pass up the Howell Series 100 Rerated motors without investigating their potentials for your machine modernization programs. They give you space savings, weight savings and new, sleek good looks—along with construction features like these: Mylar-lined slot insulation, fully protected cartridge type bearings, resilient steel frames and mounting feet, and permanently position-identified leads. These are a few of the gains; let us tell you about the rest.

Series 100 enclosures: totally enclosed fan cooled, open drip-proof, splash-proof and weather protected, sanitary, explosion-proof, and totally enclosed non-ventilated.



Illustrations above and at right show the first real advancement in motor ventilation in years—made possible by the slotted stator design of the new Howell Series 100 motors.



The thermal conductivity (K factor) of copper is 91% greater than that of aluminum. Copper's electrical resistivity is 35% less. Two good reasons for Howell's use of copper-clad rotors in Howell Series 100 motors of *all* horsepowers.

Write for new Bulletin N-100-R

HOWELL Red Band MOTORS

HOWELL MOTORS

HOWELL ELECTRIC MOTORS COMPANY, HOWELL, MICHIGAN

PRECISION-BUILT MOTORS FOR INDUSTRY SINCE 1915

—ITEM 630—

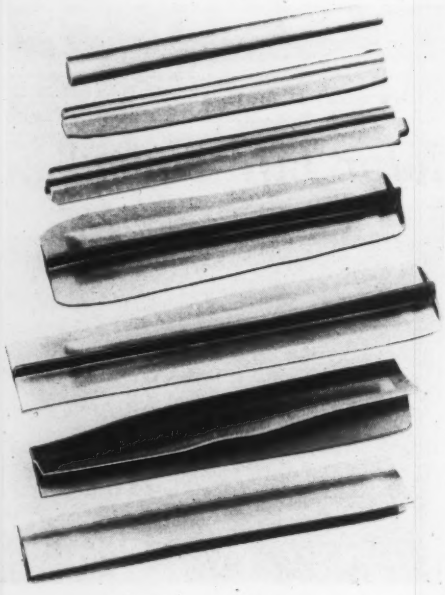


Fig. 3 — Sequence of operations in forming typical edge section, starting with round bar followed by two preforges, a splash forge, a coin roll, and two folding operations

Typical sequence of operations in producing a center section subassembly is shown in *Fig.* 5. This consists of flash-welding two center plates together, cleaning the flash and inspecting, flash-welding one edge to the center-plate assembly, cleaning and inspecting the welds, followed by flash-welding of the second edge to the previous assembly and finishing with a complete inspection of all the welds of the completed subassembly. With the exception of the machining of edges prior to joining, 90 per cent of the entire surface area of the completed part is in the as-forged condition and must be very accurately controlled dimensionally and metallurgically.

From a paper entitled "Design for Optimum Utilization of Materials" presented at the Air Materiel Command Conservation Seminar in St. Louis, October 1955.

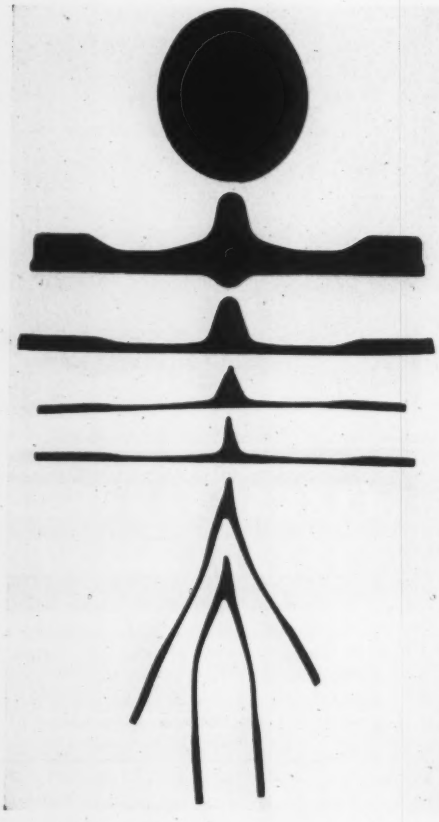


Fig. 4—Cross sections of the forming stages described in *Fig.* 3

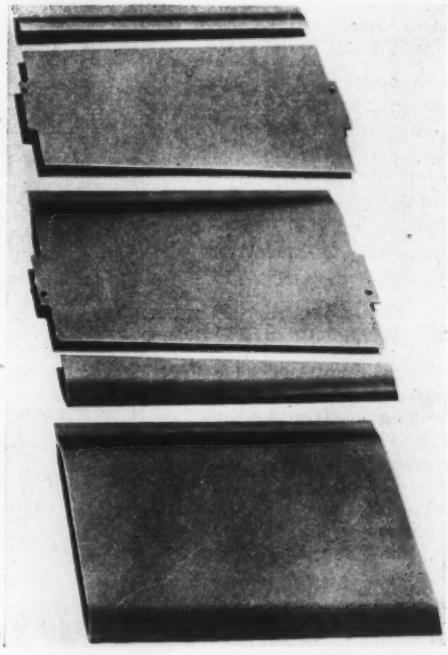


Fig. 5—Typical stages in production of center-section subassembly, consisting of flash-welding two center plates and two edge sections together

The DESIGN ENGINEERING SHOW

Convention Hall
PHILADELPHIA
May 14-17, 1956

Make it . . .

lighter . . . stronger . . .
faster . . . less expensive . . .
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more automatic . . .

Find . . .

the materials, components, fasteners, finishes, parts, shapes and forms you need to solve your design problems.

Now you can see *in action* and compare hundreds of design components —in person—in one place, under one roof. 200 outstanding progressive manufacturers will present a huge array of the things you can incorporate into the design of better products for your company. A visit to the Design Engineering Show is an *idea trip*. Exhibitors will show countless new applications of their products to suggest to you scores of ingenious solutions to your design problems. There'll be graphic demonstrations of physical, chemical and electrical properties; opportunities to discuss your needs with top technical experts; product samples available for you to test for yourself.

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THE DESIGN ENGINEERING CONFERENCE

Sponsored by Machine Design Division of the American Society of Mechanical Engineers

A three-day program with top speakers covering: cost reduction in product design; problems of design engineer procurement; selection of engineering materials; methods of miniaturization; inventions and patents.

Write for complete Conference program and registration forms.

HELPFUL LITERATURE

for Design Executives

For copies of any literature listed, circle Item Number on Yellow Card—page 19

Mechanical Letterer

The Super Varigraph mechanical lettering machine which can work with pen, pencil or knife to scribe letters up to 2 in. high is subject of folder 5591-9. Unit features ball bearing assembly, swivel knife attachment and mechanical letter spacing. It works on sheet or roll. 4 pages. Varigraph.

—Circle ITEM 401

Electrical Connectors

Construction and operational features of miniature quick-disconnect electrical connectors which lock positively without safety wiring are set forth in data sheet M1. Connector is moisture-sealed, vibration dampened, operative from −67 to 250° F and corrosion-resistant. 2 pages. Deutsch Co.

—Circle ITEM 402

Fluid Power

"How Fluid Power Serves Industry and You" discusses fluid power as the art of generating, controlling and applying the smooth, effective power of pumped and compressed fluids such as oil and air to push, pull, rotate, regulate or drive mechanisms. Typical uses are shown and described. 20 pages. Miller Fluid Power Co.

—Circle ITEM 403

Fuses & Mountings

Slo-Blo, pigtail, low voltage, instrument, automotive and aircraft Littelfuse fuses are but a few of the types detailed in illustrated catalog No. 14. Also shown are in-line retainers, holders, fuse extractor posts, various mountings, clips and circuit breakers. Proper use of fuses is covered. 20 pages. Littelfuse, Inc.

—Circle ITEM 404

Precision Gears

Production facilities and engineering services offered by this company in producing cut, generated, ground and shaved gears of all types are described in illustrated bulletin. 4 pages. Milwaukee Gear Co.

—Circle ITEM 405

Magnetic Starters

Details of a complete line of reversing and nonreversing line-voltage alternating current magnetic starters for up to 7½-hp 110 to 600-v motors are presented in bulletin 1020. Also listed are thermal overload relays for use in conjunction with the starters. 8 pages. Essex Wire Corp., RBM Div.

—Circle ITEM 406

All-Purpose Copier

Anything printed, written, drawn or typewritten as well as photos, newsprint and blueprints can be copied with the Apeco Auto-Stat all-purpose copy-maker. This one-dial controlled office machine is described in color folder. 6 pages. American Photocopy Equipment Co.

—Circle ITEM 407

Time Delay Relays

Illustrated bulletin SR-6R is descriptive of operation and shows contact arrangement for two time delay relays. Model NEL Agastat features electrical interlock, while model NEH Agastat has instant-action double throw auxiliary switch plus time delay contacts. Elastic Stop Nut Corp. of America, AGA Div.

—Circle ITEM 408

Thread Milling Machines

Complete line of semiautomatic thread milling machines that thread with one turn is descriptively covered in catalog. Information on cam action, machine specifications case histories and special adaptations is provided along with tables of feeds and speeds. 16 pages. Hanson-Whitney Co.

—Circle ITEM 409

Electrical Sheets & Strips

"Electrical Steel Sheets and Coiled Electrical Steel Strip" is title of illustrated technical bulletin EM 21. It presents such information as gage, performance guarantees, and physical and electrical properties. 28 pages. Allegheny Ludlum Steel Corp.

—Circle ITEM 410

Wear Resistant Laminate

Just how A-B-K resin-impregnated laminated fabric can be used to solve problems involving noise, impact, abrasion, excessive wear and lubrication is explained in illustrated bulletin. Physical properties are tabulated for seven grades. 6 pages. American Brake Shoe Co., American Brakeblok Div.

—Circle ITEM 411

Digital Phase Measurement

Data file 107 plots the digital method for fast, precise phase measurement. This simplified procedure reads directly in degrees, mils or any other unit of angular measure without interpolation. 12 pages. Beckman Instruments, Inc., Berkeley Div.

—Circle ITEM 412

Cemented Carbides

Crater, edge wear and shock resistance of Carmet steel cutting grades of cemented carbides are charted in folder. Other charts show properties and harness and strength vs. cobalt content. 4 pages. Allegheny Ludlum Steel Corp.

—Circle ITEM 413

Copying Equipment

XeroX copying equipment can be used to prepare masters by xerography for duplicating all types of paperwork by offset, spirit and diazo processes. Details of this process and equipment as well as procedures are presented in bulletin X260. 8 pages. Haloid Co.

—Circle ITEM 414

Speed Locknut

Everlock locknut for automotive and industrial equipment and for all types of appliances is described in folder 4052. Locknut features a "shrink-set" action which assures permanent vibrationproof lock. 6 pages. Thompson-Bremer & Co.

—Circle ITEM 415

Electric Cartridge Heating

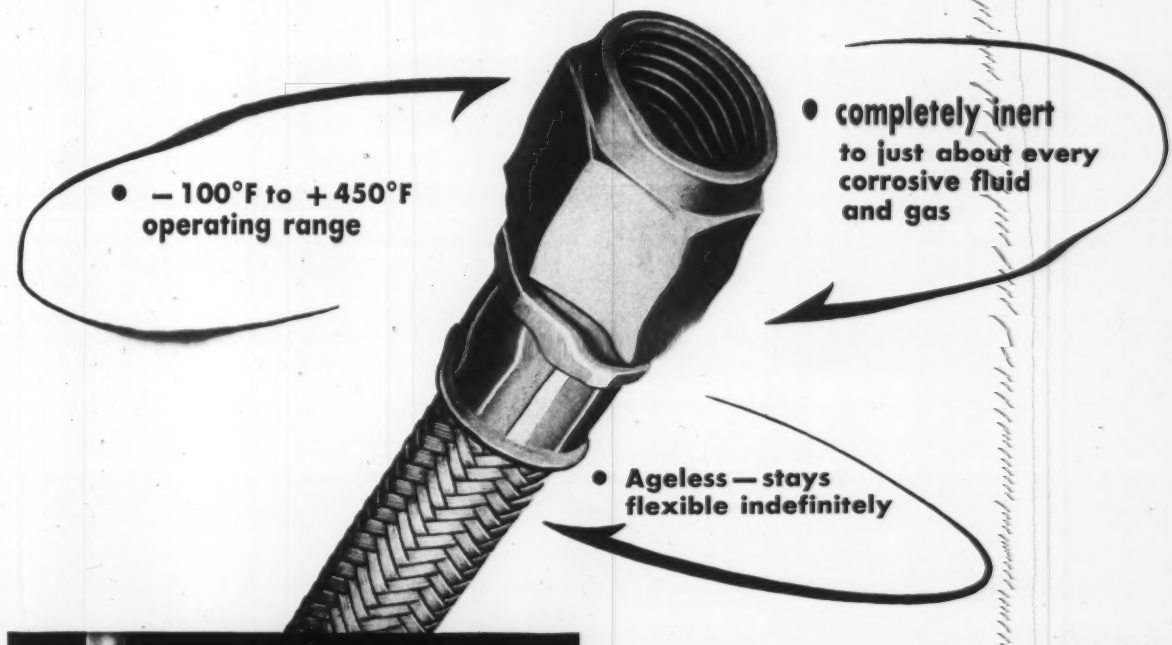
Precision cartridge heating units with ratings up to 1500 w are listed in illustrated bulletin 101. Both stainless steel sheathed and ceramic units are described. Maximum surface temperatures range up to 1250° F. 2 pages. Hotwatt Inc.

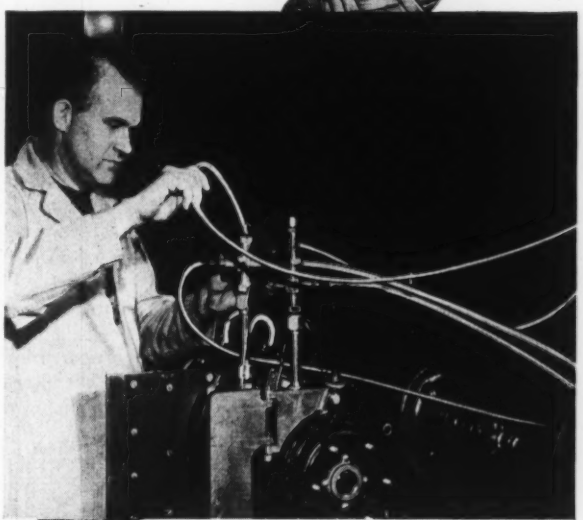
—Circle ITEM 416

Spherical Bearings

Catalog No. 55 contains design and application data on complete line of self-aligning spherical bearings and

Look at the serviceability this TEFLON® hose offers


• completely inert to just about every corrosive fluid and gas
• −100°F to +450°F operating range
• Ageless—stays flexible indefinitely



NO MORE CONTAMINATION FROM HOSE
Used on hydraulic equipment tester, Fluoroflex-T hose assemblies keep fluid clean because they don't erode. Previous lines used caused excessive replacement costs due to oil contamination.

HERE'S A hose construction for tough jobs. Flexible steam lines, lines for strongest chemicals, for the most active oils and fuels, for hydraulic fluids, for adhesives . . . these and more need no longer be a problem to you.

Inside, there's a Fluoroflex-T tube (a special compound of Teflon) which handles strongest, most active materials to 450°F! Outside, a stainless steel wire braid allows 1000 psi working pressures . . . and resists corrosion besides.

The non-aging Fluoroflex-T tube stays flexible indefinitely. It maintains an unrestricted smooth bore; doesn't swell, erode or allow build-up of deposits.

Swaged fittings are secure against blowoff or leakage. With smallest O.D. for their size, Fluoroflex-T R-3800 assemblies are easy to handle and install. They save space and weight.

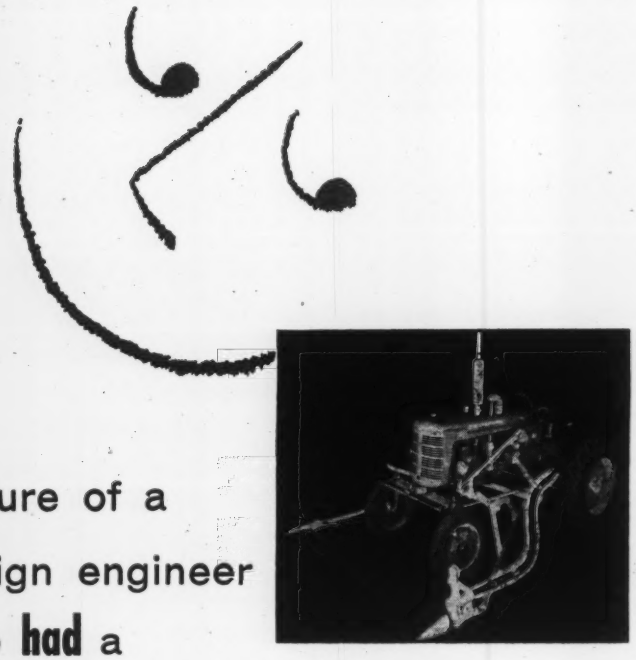
This Teflon hose opens new product-improving opportunities. Does it give *you* ideas? Send for Bulletin FH-2 which gives more data.

RESISTOFLEX CORPORATION, Roseland, N. J.; Western Plant: Burbank, Calif.

®Teflon is a DuPont trade mark. Fluoroflex is a Resistoflex trade mark.

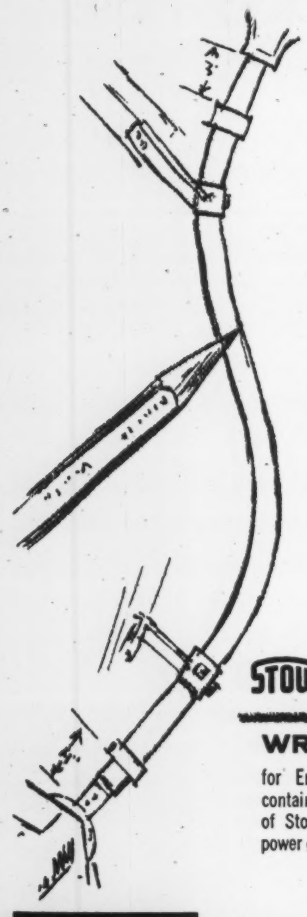
20th year of service to industry

Resistoflex



picture of a design engineer who **had** a

power transmission problem



Know who this fellow is?

We'll tell you*, but first, here are the facts about the power transmission problem he licked with STOW flexible shafting.

Briefly, this company had the problem of supplying power to a mower on a farm tractor, from the tractor's power take-off which was 7 feet away. Raising and lowering the mower further complicated the problem because of the relative motion introduced between the ends of the shaft. Further, the drive used had to be dependable, economical, easy to maintain and safe.

*This Krengle's Inc. engineer found the answer in STOW flexible shafting. 1-inch shafting, with specially designed end terminals, was used for this job.

STOW your problems—

WRITE TODAY

for Engineering Bulletin 525 containing detailed information of Stow Flexible Shafting for power drives and remote control.

STOW

MANUFACTURING CO.

Originators of the Flexible Shaft

11 Shear St., Binghamton, N.Y.

—ITEM 633—

Helpful Literature

rod ends. Aluminum bronze, steel and stainless constructions are available with up to 1-in. bores. Two and three piece rod ends are detailed. 28 pages. Aetna Steel Products Corp., Kahr Bearing Div.

—Circle ITEM 417

Multiple V-Drives

Stock sizes of multi-duty sheaves as well as sizes of non-stock, made-to-order sheaves are tabulated along with data on multi-V-belts in bulletin MVD-1000. Sheaves feature tapered bores and one-piece flanged and split detachable hubs, tapered to match. 16 pages. Maurey Mfg. Corp.

—Circle ITEM 418

Metal Moldings

Plan book of Pyramid metal moldings for industrial design illustrates end shapes of snap-on moldings; nosings, coves and edgings; card guides and trim rings; channels, angles, dividers and tees; special shapes; and end closures. Fastening methods are also shown. Moldings are roll-formed in continuous strip. 20 pages. Pyramid Mouldings Inc.

—Circle ITEM 419

Keying & Pinning Devices

Machine keys, parts, taper pins, groove pins and woodruff keys for production assembling are described briefly in folder. 4 pages. John Gillen Co.

—Circle ITEM 420

Saving Drafting Time

"11 Ways to Save Drafting Time" are outlined in pamphlet of this title. These tips include use of corrector fluids, scissor editing, block-out method, masking, using transparent matte tape, using nonreproducible blue, successive additions, pick-off transfer, composite grouping, composite overlays and preprinting. 16 pages. Frederick Post Co.

—Circle ITEM 421

Multipoint Thermocouples

Data sheet 8553 covers technical information on three basic types of Multipoint thermocouple assemblies. These units contain two or more thermocouples in a single thermowell. 2 pages. Trinity Equipment Corp.

—Circle ITEM 422

Dials & Divided Circles

Brochure tells how company has divided circles from 1 to 12-in. diameter into as many as 2000 lines per peripheral inch. How this technique is applied to dials, complex wave forms, digital computer coding

What Design Engineers Say About PHILLIPS CROSS RECESSED HEAD SCREWS

TITAN THERM-O-DIAL HEATER (Buffalo, N. Y.) is in a highly competitive market where appearance is important. Designer says, "We get a much tighter metal-to-metal bond, yet utilize a full mass-production assembly, which we could only do with Phillips screws."

"A BETTER LOOKING FIXTURE is obtained by the use of Phillips cross-recessed-head screws on our 8-Tone chime," says the chime engineer of Nutone Incorporated of Cincinnati, Ohio. "If screws must be used on the exterior of any unit, I definitely feel Phillips recessed-head screws are the very best choice."

PUSH-BUTTON STATION by Clark Controller Company, (Cleveland) must indeed be bright as a button and unmarred. Says design head, "We selected Phillips screws because they permit easy assembly with driver slippage reduced to a minimum."

MANUFACTURERS OF PHILLIPS CROSS-RECESSED-HEAD SCREWS

THE FASTENERS OF TODAY...
AND OF THE FUTURE
X marks the spot
the mark of extra quality

Pledged to highest standards...

The Phillips Screw manufacturers listed here cooperate to turn out a uniformly high standard of quality. As sponsors of the Phillips Cross-Recessed-Head Standards Committee they adhere to the established dimensional standards, gauges, and gauging methods which will best serve industry.

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20 years of

OUTSTANDING PERFORMANCE

Have made Durakool Tilt-Switches and Timer-Relays the Recognized Standard of Industry

Now celebrating its 20th year, Durakool, Inc., is proud of the many records of achievement set by its mercury tilt-switches and timer relays.
The basic "Sealed under pressurized hydrogen" principle has been proved on thousands of applications. So successful have they been that they are now the accepted standard of the industry:

- **Millions of contacts or cycles without faltering**
- **Outlasts the normal equipment life**
- **Trouble free under every practical temperature or humidity condition.**
- **The tougher the assignment, the more Durakools stand out.**

For detailed information about your exact application WRITE TODAY.

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VISIT OUR BOOTH NO. 520 AT THE DESIGN ENGINEERING SHOW PHILADELPHIA, MAY 14-17

Helpful Literature

disks and sine wave frequency standards is discussed. 4 pages. Precision Photomechanical Corp.

—Circle ITEM 423

Phenolic Molding Compounds

Physical properties of Durez molding compounds are presented in brochure "Facts on Phenolics." Given are powder, molded material and electrical properties of general purpose, medium and high impact, electrical insulating and other materials. 16 pages. Hooker Electrochemical Co., Durez Plastics Div.

—Circle ITEM 424

Electronic Timers

Standard line of electronic timers described in brochure includes delay, repeat cycle and interval types. Current information and specifications are given. 6 pages. G. C. Wilson & Co.

—Circle ITEM 425

Screws, Studs & Nuts

Hexagon, fillister, flat head cap screws, set screws, socket screws, milled studs and hexagon nuts are described and illustrated in list price schedule No. 54A. Materials are steel, silicon bronze, stainless steel and brass. Specifications and prices for all types and sizes are given. 24 pages. Cleveland Cap Screw Co.

—Circle ITEM 426

Hoses & Ducts

Flexaust hoses and Portovent ducts for dust collection, fume control, air conditioning and materials handling are briefly described in illustrated bulletin No. 60. Prices for each of the various types and application and installation data are given. 6 pages. Flexaust Co.

—Circle ITEM 427

Ferrous Pipe & Tubing

Maximum allowable stress values for ferrous pipe and tubing are presented in technical data card 154A. Covered are seamless and welded carbon, alloy and stainless steel tubing and pipe. Temperature ratings from —20 to 1500° F are included. 6 pages. Babcock & Wilcox Co., Tubular Products Div.

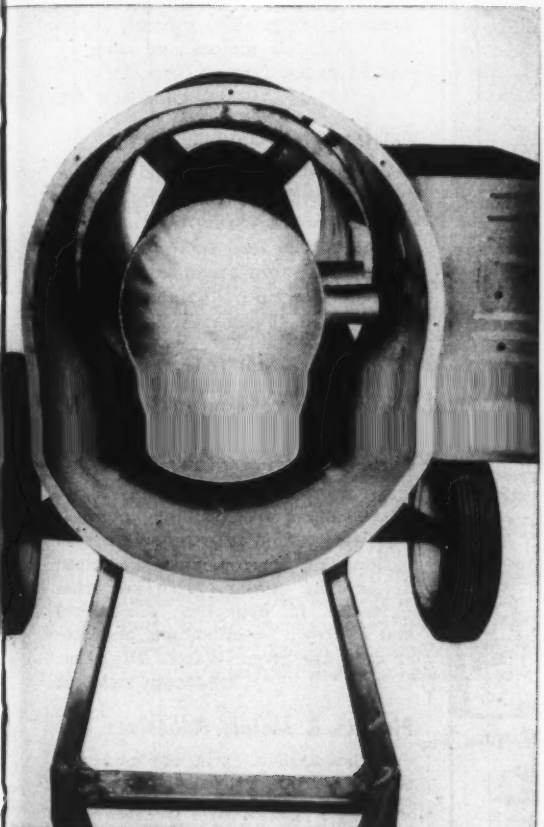
—Circle ITEM 428

Oscillograph

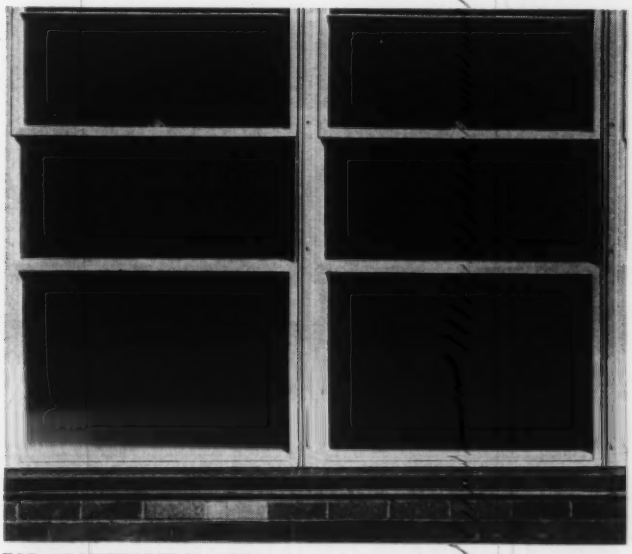
Seventy-one galvanometers in two banks which provide a wide selection of sensitivities and frequencies for recording many variables on one oscillogram are feature of PM-20 general purpose oscillograph. Other design features are also described in illustrated bulletin GEA-6348. Gal-

FOR TRAILERS THAT DO NOT WEAR OUT. This Fruehauf trailer has sides made from thin sheets of Stainless Steel, corrugated into walls that are only one inch thick. That's why it can carry more cargo than trailers of other, heavier types of construction. Most joints are welded, an easy job with Stainless. There is nothing to corrode or loosen; in fact, no Stainless trailer has ever worn out!

NOTHING *can equal Stainless Steel*



FOR HEAT RESISTANCE. This is a Lennox Crop Dryer. It burns 12 gallons of fuel oil per hour and has an input of 2,000,000 BTU. Wherever the heat is most intense, type 430 Stainless Steel is used. It is especially important for the combustion chamber and emitting tubes.



FOR ARCHITECTURAL USE. This Dawson Floating Sill is made from type 302 Stainless Steel. It combines fine appearance with the enduring properties of Stainless Steel. The finished job is neat and trim, and it will last as long as the building.

UNITED STATES STEEL CORPORATION, PITTSBURGH • AMERICAN STEEL & WIRE DIVISION, CLEVELAND
COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO • NATIONAL TUBE DIVISION, PITTSBURGH
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA.
UNITED STATES STEEL SUPPLY DIVISION, WAREHOUSE DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS STAINLESS STEEL

SHEETS • STRIP • PLATES • BARS • BILLETS
PIPE • TUBES • WIRE • SPECIAL SECTIONS

USS

UNITED STATES STEEL

From DIALCO—New, Compact

OIL TIGHT

INDICATOR LIGHTS

for heavy duty industrial applications

OIL TIGHT

DUST TIGHT

OMNIDIRECTIONAL

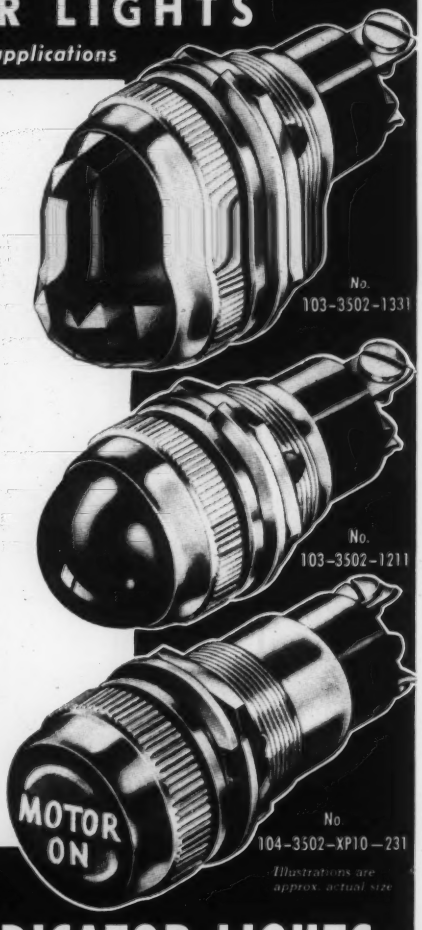
Exceptionally Rugged!

Perfect oil-tightness is effected by retained oil-proof gaskets and the gasketed glass lens assembly.

These units have many heavy-duty features: *One-piece solid brass bushing, solid brass lens holder, high impact phenolic insulation, rugged binding screw terminals.*

They install easily in a single 1" or 1 3/16" panel mounting hole. Other units available for 1 1/16" mounting hole. *A choice of 3 lens styles, 7 lens colors,* and other optional features provide adaptability. If you have an unusual problem, consult our engineering department.

DISCS with legends, behind flat lenses, deliver specific messages.



Illustrations are approx. actual size

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accommodate a wide range of Incandescent and Neon Glow Lamps. For neon, DIALCO offers an exclusive feature — *BUILT-IN RESISTORS* (U. S. Patent No. 2,421,321) for operation on 105-125 V, or 210-250 V. Simple external resistors are provided for all higher voltages. *EVERY ASSEMBLY IS AVAILABLE COMPLETE WITH LAMP.* For design purposes we will send :

SAMPLES ON REQUEST—AT ONCE—NO CHARGE

CATALOG "L-200" gives you complete specs on DIALCO'S Oil-Tight Indicator Lights. Also available—a file of Special Catalogs on DIALCO Pilot Lights covering every indication requirement.

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Name_____

Company_____

Address_____

City_____ State_____

Helpful Literature

vanometer coverage is for frequencies up to 6000 cps. 16 pages. General Electric Co.

—Circle ITEM 429

Relays

Relays for industrial electromechanical switching are described and illustrated in bulletin T-5000. All data necessary for ordering are included on types A, B, C, D and 340 polar relays. 24 pages. Stromberg-Carlson Co.

—Circle ITEM 430

Rubber Linings

Corrosion, abrasion and contamination resistant rubber linings for tanks, pipe, valves and storage and process equipment is subject of illustrated catalog 7115. Many charts, tables and diagrams are included. Raybestos-Manhattan, Inc., Manhattan Rubber Div.

—Circle ITEM 431

Air & Vacuum Pumps

Details of construction, dimensions, capacities and performance curves on line of Leiman rotary air and vacuum pumps are found in illustrated catalog 755. Included are four-wing, two-wing and double-cylinder types, motor driven models, integral pump and motor, air motors and accessories. 12 pages. Leiman Bros., Inc.

—Circle ITEM 432

Air Operated Equipment

Valve-in-head, single and double-ended air cylinders; solenoid, pilot and hand air valves; spring return clamps and three dial feed table models are featured in spiral bound catalog compilation. Descriptive data and prices are included. 40 pages. A. K. Allen Co.

—Circle ITEM 433

Wire Wound Potentiometers

Resistances ranging from 10 to 100,000 ohms are available in precision wire wound potentiometers with bushing or servo-mounts, described in Aerohm catalog. Sizes are from ½ to 1⅛ in. diameter. Mechanical and electrical specifications and other data are given. Waters Mfg., Inc.

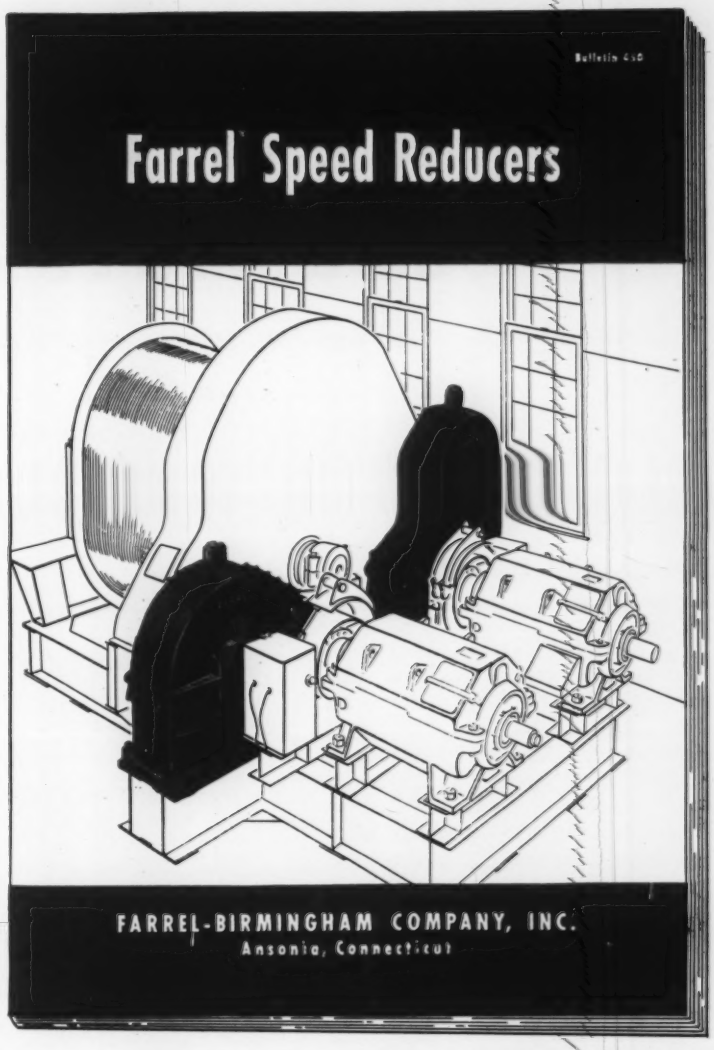
—Circle ITEM 434

Plastics & Metals Adhesives

Technical data, form, percentage of solids, average viscosity, fastest optimum curing time, lowest optimum curing temperature and application suggestions for 30 adhesive formulations are listed in data chart. Use is for bonding plastics and metals to themselves and each other. Rubber & Asbestos Corp.

—Circle ITEM 435

NOW... 52 PAGES OF DATA



for efficient drive selection and application

All the information you need for quick selection of speed reducers for any application is in this comprehensive new book. Included are specifications, horsepower rating tables, overhung load capacities, dimensions and weights of the large variety of units comprising the Farrel line. This line has been recently re-engineered, rerated and expanded.

Design features of Farrel single, double and triple reduction units are described. Examples: Farrel-Sykes precision-generated, continuous-tooth herringbone gears—the famous *Gear with a Backbone;* rigid and accurately ground shafts properly mounted in roller bearings; and heavy section cases that hold rotating elements in precise alignment.

If you buy or specify speed reducers, this handy manual is a must. For your free copy, fill in the coupon below, and drop it in the mail today.

FARREL-BIRMINGHAM COMPANY, INC., ANSONIA, CONN.
Plants: Ansonia and Derby, Conn., Buffalo and Rochester, N. Y.
Sales Offices: Ansonia, Buffalo, New York, Boston, Akron, Detroit, Chicago, Minneapolis, Fayetteville (N. C.), Los Angeles, Salt Lake City, Tulsa, Houston

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Please send me, without cost or obligation, a copy of your new bulletin No. 450, "FARREL SPEED REDUCERS."

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Company_____
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City_____ State_____

FB-1061

—ITEM 638—
For More Information Circle Item Number on Yellow Card—page 19

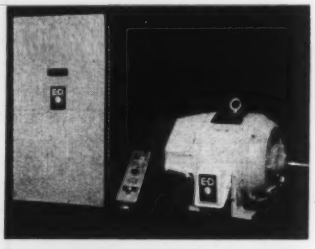
New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Variable-Speed Drive

holds motor speeds to 0.25 per cent

New Selectron variable-speed drive has fast response, stepless control, load compensation and wide speed range. Normal speed range is 22:1, with ranges as high as 60:1 available on request. With tachometer feedback, speed can be controlled to within 0.25 per cent.



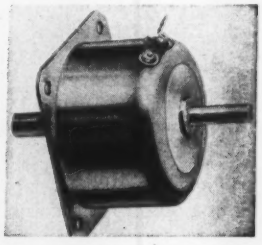
Optional features include dynamic braking, reversing, and inching control. Drive motors are heavy-duty, ball-bearing industrial types in standard NEMA frames and are available with the usual motor modifications to meet special application problems. Power supply is single-phase 50 or 60-cycle ac, 110 to 550 v. **General Dynamics Corp.**, Electro Dynamic Div., Bayonne, N. J.

—Circle ITEM 461

Rotary Solenoid

available with range of torque characteristics

Snap-action rotary solenoid, designated PACSOL, can be used to operate release mechanisms, valves, or other devices requiring high-torque, snap-action forces. It can also be coupled by clutch or overriding ratchets to the driven load, providing incremental advance-



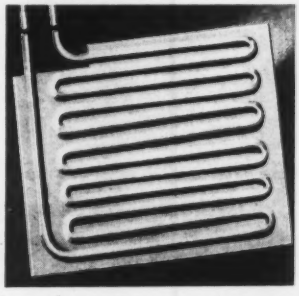
ment through 360 deg. User can obtain any torque curve needed—whether flat or with high torque either at start or finish of stroke. Torque ratings to 15 lb-in. and shaft rotations from 5 to 60 deg in either direction are available. Units can be adapted to a range of direct-current inputs in both intermittent and continuous-duty models. Dimensions are 1-13/16-in. diam by 1⅜-in. long. **Pacific Solenoids Inc.**, 208 Standard St., El Segundo, Calif.

—Circle ITEM 462

Heat Exchanger

is only ⅞-in. thick

Designed as a substitute for pipe coils in industrial processes requiring application or removal of heat, this Platecoil heat-transfer



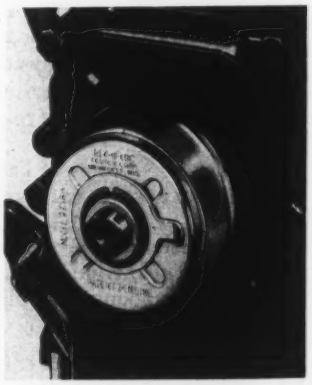
unit consists of two embossed metal sheets welded together to provide a preformed channel for the flow of heating or cooling media. Threaded connections are above the solution level, facilitating removal for cleaning or inspection. Unit is available in 18 or 22-in. widths and in lengths from 23 to 119 in. Overall thickness is ⅞-in. Platecoils can now be supplied in type-316 stainless steel, Monel, Carpenter 20, Hastelloy B and C, nickel, or cold-rolled steel. **Tranter Mfg. Inc.**, Platecoil Div., 733 E. Hazel St., Lansing 4, Mich.

—Circle ITEM 463

Automatic Clutch

with engage-release speed differential

Type 275 AV automatic V-belt clutch for gasoline engine and electric motor applications up to 2 hp utilizes belt pull to increase clutch capacity and to provide a speed differential between engagement and release. Using the V-belt as the friction element, the

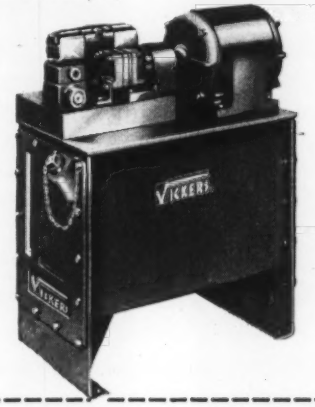


clutch employs mechanical action to achieve greater gripping power against the V-belt and to lock the clutch in engagement. Disengaging speed is lower than engaging speed, permitting high-speed starting at maximum torque. Pick-up of the V-Belt is smooth and positive. All parts are metal; parts subject

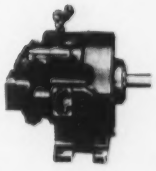
What's New in VICKERS HYDRAULICS

Illustrated here are new and recently improved units added to Vickers most complete line of oil hydraulic equipment. Look to Vickers as a single responsible source for integrated hydraulic systems. For characteristics of any of these components, please write for Installation Drawings by number.

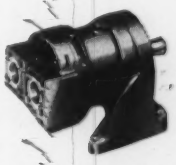
SERIES T8 PIPELESS POWER PACKAGE consists basically of electric motor, hydraulic pump, control circuit and reservoir. Available in 3 circuits, 3 pump sizes and 3 electric motor sizes. Inst. Dwgs. 178706, 7 & 8.



V-LINE PISTON PUMPS AND MOTORS for 5000 psi. Unique design minimizes relative movement between rotating parts, provides increased bearing surfaces and reduces complexity of parts. Result is improved efficiency, longer life, and reduced maintenance. Supplied with straight thread connections. Bulletin 55-72.

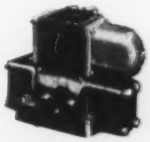


Variable Displacement Pump With Servo Control. Inst. Dwg. 179061. Also available with pressure compensator control. Inst. Dwg. 179060.



Constant Displacement Fluid Motor. Inst. Dwg. 179069. Available also is a Constant Displacement Piston Pump. Inst. Dwg. 179058.

DG4S4 ⅜" solenoid operated. Inst. Dwg. 182412. ¼" available later.



DG5S4 ¾" solenoid controlled pilot operated. Inst. Dwg. 182413. 1¼", 2", 3" available later.

SOLENOID OPERATED 2- AND 4-WAY VALVES with many improved features. (1) Integral junction box (2) covers that retain the solenoids and (3) manual operation for testing. Compact and versatile. Gasket mounting simplifies installation and overhaul . . . also minimizes piping.

TRAVERSE AND FEED CYCLE CONTROL PANEL Improved design. Provides any cycle sequence of rapid advance, adjustable feed, dwell and rapid return motions. Maintains smooth and constant preset feed rate (either one or two) regardless of fluctuations in cutting tool resistance or hydraulic pressure.

CPP-2242 Solenoid Controlled. Pilot Operated (gasket mounted) provides smooth, low current operation. Inst. Dwg. 182414.

CG-03 Relief Valve (gasket mounted). Subplates available with pipe or straight thread connections. Inst. Dwg. 175630. CS-03 available with straight thread connections. Inst. Dwg. 175629.

C02 Reciprocating Cycle Control Panel For Gasket Mounting. Inst. Dwg. 177083.

4CG-03 Pilot Operated Check Valve, gasket mounted. Inst. Dwg. 135468.

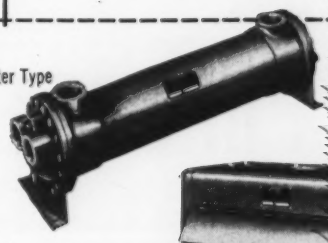
CG-714 Deceleration Valve, gasket mounted. Inst. Dwg. 172902.

CGV-06 5000 psi Relief Valve gasket mounted with straight thread connections. Inst. Dwg. 177609.

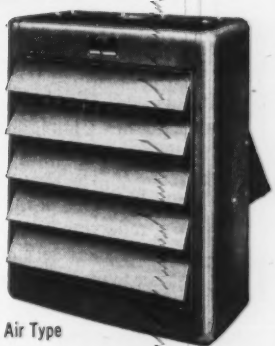
URG1 Unloading Relief Valve, gasket mounted. Inst. Dwg. 178974.

SG1 Pressure Switch, gasket mounted. Inst. Dwg. 172538.

Water Type



OIL COOLERS Vickers Oil Coolers are characterized by their very high rate of heat transfer per unit of space occupied. Bulletin 55-69.



Air Type

For further information on any unit shown, ask for Installation Drawing by number indicated. 7435

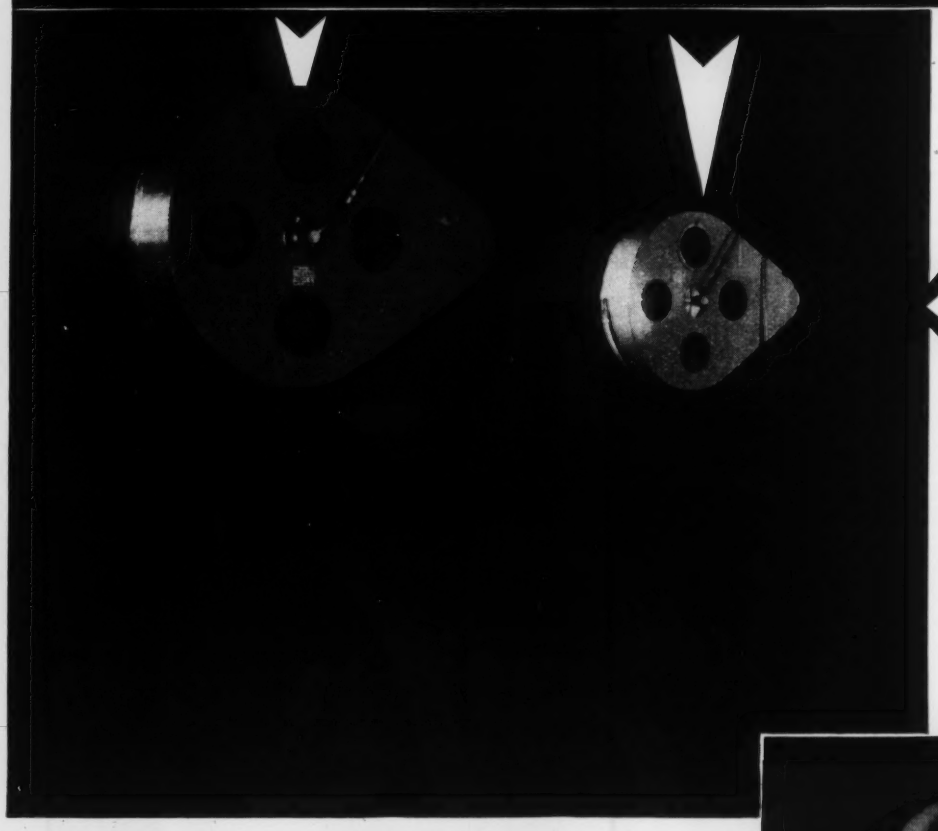
VICKERS INCORPORATED
DIVISION OF SPERRY RAND CORPORATION
ADMINISTRATIVE and ENGINEERING CENTER
Department 1430 • Detroit 32, Michigan

Application Engineering Offices: • ATLANTA • CHICAGO CINCINNATI • CLEVELAND • DETROIT • HOUSTON • LOS ANGELES AREA • (El Segundo) • MINNEAPOLIS • NEW YORK AREA (Summit, N.J.) PHILADELPHIA AREA (Media) • PITTSBURGH AREA (Mt. Lebanon) PORTLAND, ORE. • ROCHESTER • ROCKFORD • SAN FRANCISCO AREA (Berkeley) • SEATTLE • ST. LOUIS • TULSA • WASHINGTON • WORCESTER
IN CANADA: Vickers-Sperry of Canada, Ltd., Toronto

ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

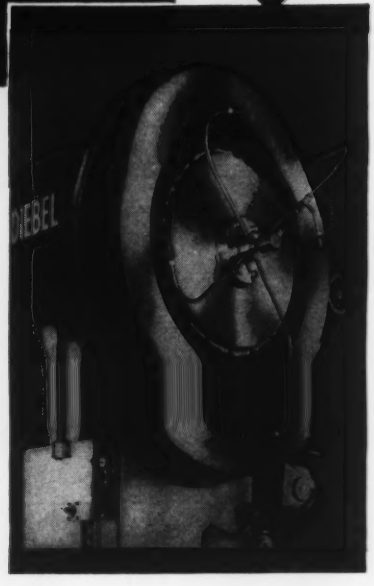
FAWICK Airflex

IN THE METALWORKING INDUSTRY



These Diebel 60-ton Automatic Presses are equipped with Fawick Type 22CB500 Clutches and 15CS300 Brakes for faster, more accurate production.

The famous Fawick Type CB Air-actuated Clutch installed on Diebel Automatic Press.



producing SIX days work in FIVE!

That's the record FAWICK-EQUIPPED Diebel 60-Ton Automatic Presses are making for a large Midwest manufacturer of electric components.

FAWICK Airflex Clutch and Brake units and Controls contribute importantly to other records produced by these outstanding Diebel Automatics! Reports from the user state:

". . . 30% increased production between die grinds"
". . . 30% reduction in labor costs on laminations"
". . . downtime and set-up time cut in half"
". . . maintenance costs are next to nothing"

These are typical of reports from operators of FAWICK-EQUIPPED metalworking machines throughout industry.

If you are interested in better production at lower cost, investigate the outstanding advantages of FAWICK products today. Simply call or write the Home Office or your nearest FAWICK representative.

Remember—"*It works best when* FAWICK-EQUIPPED"

FAWICK AIRFLEX DIVISION
FAWICK CORPORATION
9919 CLINTON ROAD • CLEVELAND 11, OHIO
In Canada: Fawick Canada, Ltd., Toronto, Montreal

FAWICK Airflex
INDUSTRIAL CLUTCHES AND BRAKES

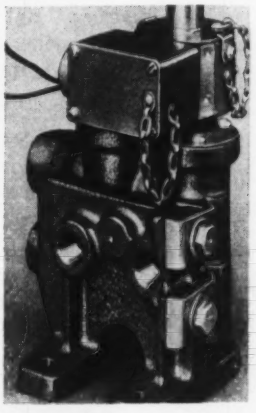
—ITEM 640—
For More Information Circle Item Number on Yellow Card—page 19

to wear are hardened, permanently lubricated and cadmium plated. The unit is available with ½, ⅝ and ¾-in. bore, and pulley diameter of 2¾ in. **Rev-O-Loc Clutch Corp.**, P. O. Box 1806, Milwaukee 1, Wis.

—Circle ITEM 464

Solenoid Valve

controls air, water and light oil to 150 psi



Crescent four-way solenoid valve, conforming to JIC specifications, is inoperative when its cover is removed, and manual override is safe against accidental actuation. Conduit connector is threaded; pressure ring terminals are on 6-in. free leads. The solenoid and junction box are protected by captive cover plates against airborne contamination. By loosening three body clamps, the valve is removed from the sub-base. Free port area aproximates the pipe area, thereby reducing pressure drop. The solenoid is interchangeable with standard solenoids. Coil change makes possible conversion of the valve to any current or voltage, ac or dc. Short stroke, pilot operation and large power margin eliminate coil burnout. **Barksdale Valves,** 5125 Alcoa Ave., Los Angeles 58, Calif.

—Circle ITEM 465

Threaded Insert

for plastics, die castings and potting compounds

When molded into plastics, rubber, die castings and potting compounds, this insert requires no secondary operations for inserting or locking. It is knurled to prevent rotation, and additional strength

against pullout is provided by two circular relief bands. Sizes available range from No. 2 to ⅜-in. with both NC and NF threads. Tapped straight through and blind styles with Class 2 threads are standard; Class 3 threads can be furnished if required. Standard material is brass, but insert can be made to order from steel, aluminum or stainless steel. **Standard Insert Co.,** 12270 Montague St., Pacoima, Calif.

—Circle ITEM 466

Aluminum Foil

is Teflon-insulated

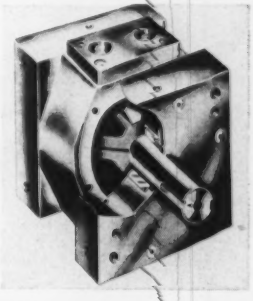
Amfoil, consisting of Teflon-coated aluminum in thicknesses from 0.2 to 2.0 mil, has many electrical and electronic applications, and can also be used for flexible packaging. Coating thickness is varied from 0.03 to 0.5-mil on each side of the foil and held to ±10 per cent of desired film thickness. The dielectric, high-temperature (200 C) material is chemically inert and nonadhesive. It is available in sheet widths up to 40 in. **American Machine & Foundry Co.,** Commercial Development Div., 261 Madison Ave., New York 16, N. Y.

—Circle ITEM 467

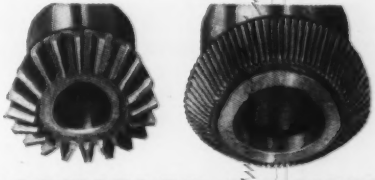
Torque Motor

provides 280-deg shaft oscillation or rotation

Roto-Mation oscillating torque motor is applicable for turning, opening, closing, clamping, indexing, or



New

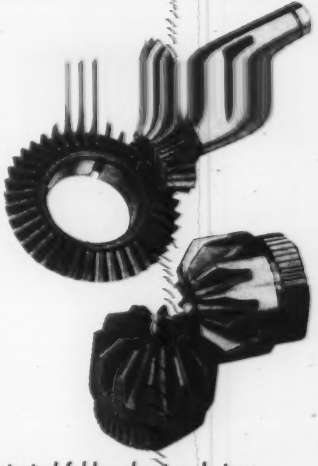


BEVEL GEARS BY CONIFLEX METHOD

MASS GEAR'S new Coniflex

Straight Bevel Gears save you assembly time and money by permitting a tolerance in mounting.

Coniflex Straight Bevel Gears in effect have a crowned tooth. Therefore, a small displacement of gears under operating loads is possible without concentration on the ends of the teeth.



Send for illustrated folder, showing designs and gear combinations available.

Massachusetts Gear & Tool Co.
WOBURN, MASS.

—ITEM 641—

PRODUCT DESIGN WITH DUREZ PHENOLICS

These parts

SAVE MONEY

and **WEIGHT**

...engineered with **DUREZ** *phenolic*

● When planning products with low fabricating costs, light weight, and attractive appearance in view, consider how easily all three were obtained with Durez in this heavy-duty power plane.* Parts like these when made of metal required drilling, tapping, buffing, and polishing.

With Durez these operations were eliminated—weight was reduced, and the parts will keep their rich black molded-in luster through years of wood-working wear and tear.

The important properties and benefits available in these engineering plastics have earned them preference for thousands of applications.

Large parts, small parts... parts where self-insulation, impact strength, and resistance to heat, moisture, and chemicals are vital.

Talk with your molder... and write for our latest technical booklet, "Facts on Phenolics."

DUREZ®

Phenolic Plastics that fit the job

DUREZ PLASTICS DIVISION

HOOKER ELECTROCHEMICAL COMPANY
504 WALCK ROAD, NORTH TONAWANDA, N. Y.

HOOKER® CHEMICALS & PLASTICS

**Super-Power Porta-Plane by Porter-Cable Machine Co., Syracuse, N. Y.*

New Parts

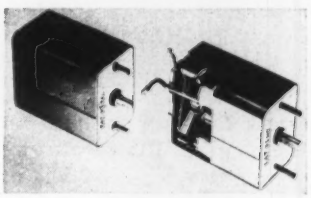
moving any type of load or mechanism. Maximum shaft rotation is 280 deg. Unit can be operated by air, oil, or any fire-resistant fluid. Mountings can be made on any of the six faces of the motor, and 14 different mounting arrangements can be provided. Ambient temperature limit is 650 F. Operating pressure range is 0 to 1500 psi; higher pressure ratings can be furnished on order. **Roto-Mation Motors Inc.**, Greenville, O.

—Circle ITEM 468

Rectangular DC Motor

uses axial flux path to reduce frame size

Designed for application where space is limited, line of rectangular



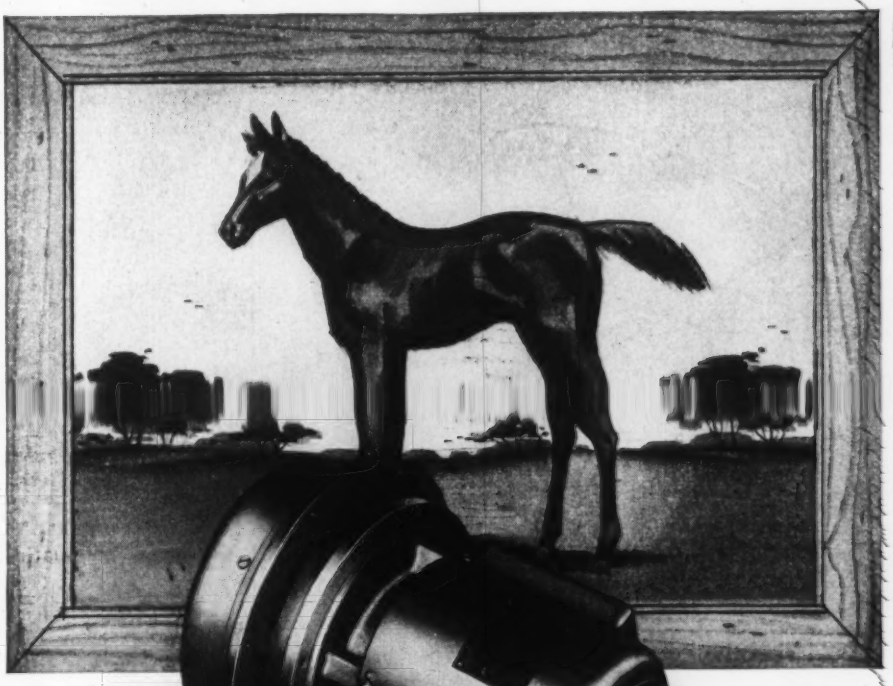
direct-current motors provides torque outputs to 140 oz-in. Inputs range from 6 to 32 v. Rectangular housing is made practicable by use of an axial flux path rather than the conventional concentric path. Armature and bearing misalignment is eliminated by the motor-housing construction, which consists of 3/16-in. thick welded stampings. Flat surfaces of housing permit the motor to be mounted in any position. Optional are double-ended shaft extensions and waterproof construction. **Leece-Neville Co.**, 1374 E. 51st St., Cleveland 3, O.

—Circle ITEM 469

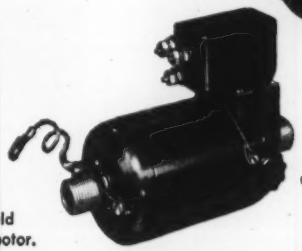
Hollow Aluminum Bars

have wall thicknesses from 0.109 to 0.500-in.

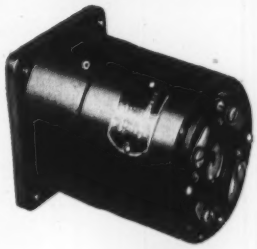
Hollow aluminum bar stock is available in standard diameters from 1 to 2½ in. (1/16-in. increments), diameters from 2⅝ through 3½ in. are furnished in ⅛-in. increments. Wall thickness of rounds vary from 0.109 to 0.500-in. Aluminum alloy utilized



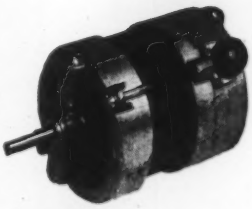
Explosion-proof vacuum unit.



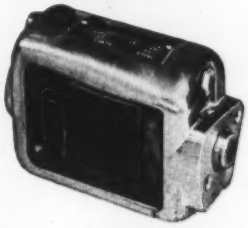
Aircraft windshield wiper motor.



Radar voltage regulator gear motor.



Weight-saving home appliance motor.



For motor-driven office equipment.

Thoroughbred, Fractional HORSEPOWER

for your motor-driven products

The unexcelled performance of Lamb Electric Motors in many types of industrial, commercial and domestic products is evidence of their outstanding quality.

Dependability and efficiency (optimum weight-size-horsepower ratio) are features that result from proper design and careful manufacture by personnel having many years of experience in the small motor field.

May we demonstrate how Lamb Electric Motors can bring these advantages — and also perhaps lower costs — to your products?

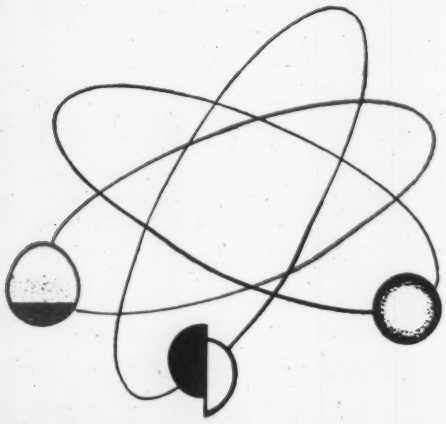
THE LAMB ELECTRIC COMPANY • KENT, OHIO

In Canada: Lamb Electric—Division of Sangamo Company Ltd.—Leaside, Ontario

If you are interested in any of the above motors write and we shall be glad to send full information.

Lamb Electric

SPECIAL APPLICATION FRACTIONAL HORSEPOWER **MOTORS**



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ESCO GUIDE TO

COST REDUCTION

in the use of stainless and alloy steels for the manufacturing and process industries

CORROSION • HEAT • IMPACT and ABRASION

... whatever the problem, processing, or manufacturing end products, this 100-page book will suggest new and better solutions which can mean immediate cost reductions, increased efficiency and often a superior process or product.

Over 47 pages of specifications, alloy chemical composition and physical properties and handy reference tables and charts on corrosion, heat and abrasion resistant alloys.

The only book of its kind. Here also is the latest information on static, shell molding and centrifugal casting of alloy and stainless steels for all industry.

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ESCO

—ITEM 644—

New Parts

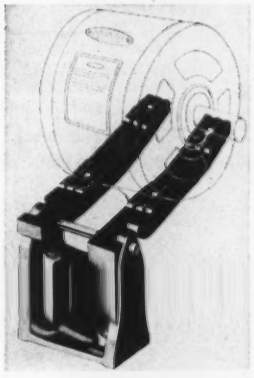
for this machining stock is 6066, a wrought alloy with excellent machinability and high corrosion resistance. Typical yield strength is 52,000 psi. **Harvey Aluminum,** 19200 S. Western Ave., Torrance, Calif.

—Circle ITEM 470

Motor Base

maintains belt tension for all load conditions

Auto-Tension quiet-operating motor base automatically compen-



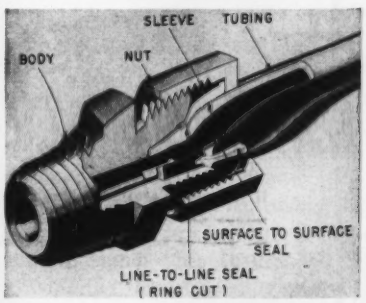
sates for belt stress and maintains belt tension to reduce wear on belts and bearings. Belts can be changed without disturbing the mounting. Designed for use with horizontally positioned drives, the base is available in four NEMA motor frame sizes from 1/6 to 7½ hp. **Lovejoy Flexible Coupling Co.,** 4818 West Lake St., Chicago 44, Ill.

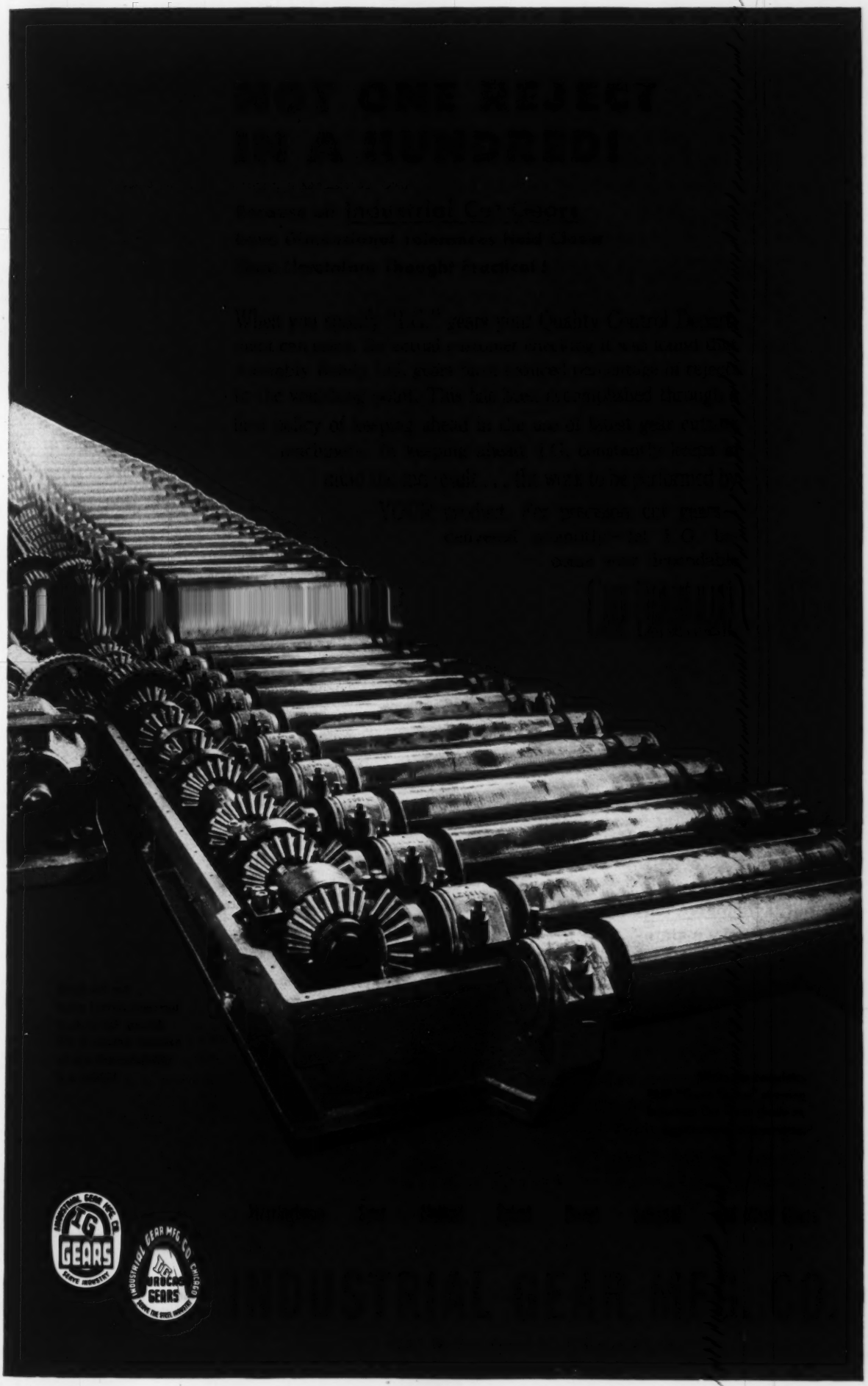
—Circle ITEM 471

Tube Fitting

is installed without disassembly

Dual sealing in this Selfalign tube fitting assures positive, leakproof connections. Sleeve grips the tubing for a surface-to-surface seal; thin edge and guiding shoulder form a line-to-line seal with the




IG
GEARS
INDUSTRIAL GEAR MFG. CO.
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GEARS
INDUSTRIAL GEAR MFG CO CHICAGO

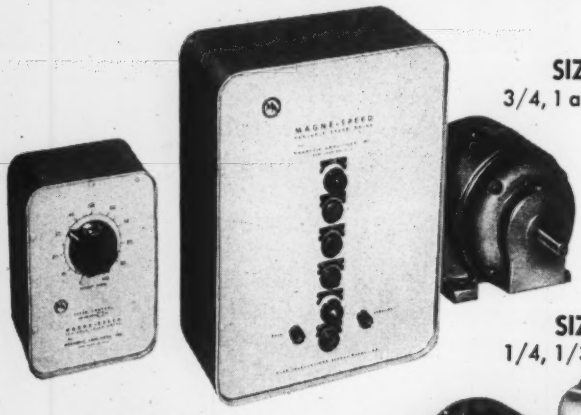
AFFILIATE OF
GENERAL CERAMICS
CORPORATION

Magnetic Amplifiers · INC

—announces its new

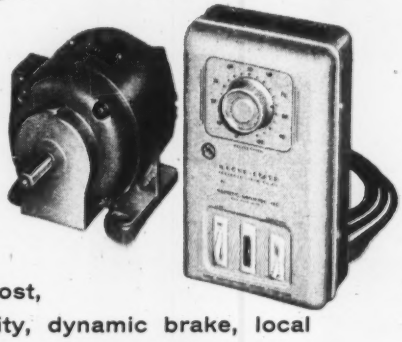
VARIABLE SPEED DRIVE

MAGNE-SPEED*



SIZE II —
3/4, 1 and 1-1/2 HP

SIZE I —
1/4, 1/3 and 1/2 HP



Stepless, instant starting, compact, 50:1 speed range, good regulation without tachometer, long life, virtually maintenance free service, low cost, fast response, reversibility, dynamic brake, local or remote control. Write for Bulletin S580-5-55.

Other MA *Products and Services*

Magnetic Servo Amplifiers
Transi-Mag * Amplifiers
Analog Computors
Photoelectric Controls
DC and AC Regulated Power Supplies

* Trade Name

Application engineering and conversion of tool machines and production processes to automatic control.

Magnetic Amplifiers • Inc
Tel. CYpress 2-6610 • 632 TINTON AVE., NEW YORK 55, N. Y.

New Parts

tubing as the nut is tightened. Tubing is inserted in the fitting until it bottoms and the nut is tightened. Fitting is suited for low and medium-pressure applications using copper and aluminum tubing. Complete line includes union, union tee, union elbow, male and female connectors, male and female elbows, male tees for pipe on run and pipe on branch. Sizes from ⅛ to ½-in. are available in brass and aluminum. **Weatherhead Co.**, Ft. Wayne Div., 128 W. Washington, Ft. Wayne, Ind.

—Circle ITEM 472

Motor-Winding Thermostat

interrupts magnetic starter when winding temperatures rise

Hermetically sealed, snap-action thermostat, model C4344-28, is attached directly to the end turns of large polyphase motor windings prior to winding impregnation and baking. Purpose is to interrupt the magnetic starter when a temperature rise in the windings is not detected by a remotely-located overload relay. The thermostat

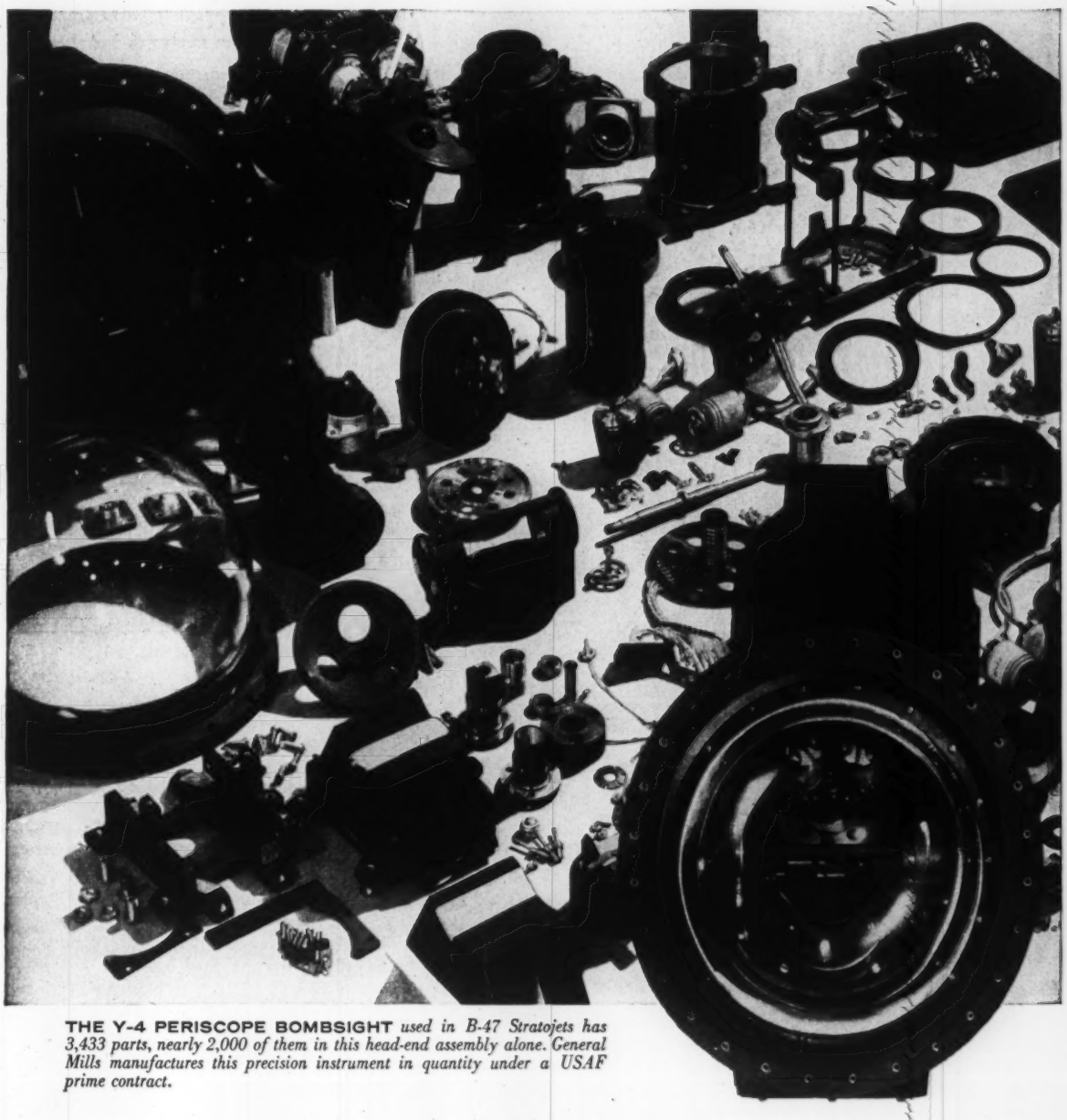
provides full running protection under all conditions of overheating in which the temperature rise is gradual. It withstands vacuum impregnation and baking at maximum temperatures to 500 F. Adequate insulation is provided for 600-v protection. **Metals & Controls Corp.**, Spencer Thermostat Div., Attleboro, Mass.

—Circle ITEM 473

Solenoid Valve

with 100 basic model variations

Variations that can be provided in this J.I.C. multi-purpose spool-valve design are: ¼ or ⅜-in. pipe tap; manifold or base mounting;



THE Y-4 PERISCOPE BOMBSIGHT *used in B-47 Stratojets has 3,433 parts, nearly 2,000 of them in this head-end assembly alone. General Mills manufactures this precision instrument in quantity under a USAF prime contract.*

No need to swamp your staff with piece part and assembly problems...

Let General Mills supply the whole package

Eliminate the thousands of detail problems involved in turning out complete electro-mechanical assemblies—and save money, too!

The Mechanical Division of General Mills is ready to manufacture or purchase component parts, assemble to your requirements, and deliver assemblies performance-tested to rigid Government standards—on time. We have the experience and equipment required to take over the complete job. The highest precision standards are maintained in engineering, manufacture, quality control, packaging and accounting.

LET US BID on your requirements. Write, wire or phone: Dept. MD-3, Mechanical Division of General Mills, Inc., 1620 Central Ave., Minneapolis 13, Minn. STerling 9-8811.

Job opportunities available for creative engineers. Work closely with outstanding men on interesting projects.

MECHANICAL DIVISION OF General Mills

—ITEM 647—

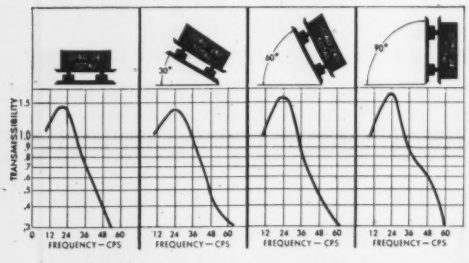
WILL MIL-SPEC MOUNTS WORK

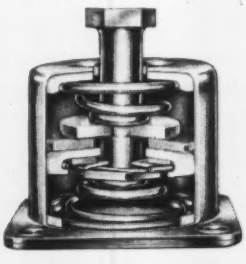
when you need protection most — at steep-angle attitudes?

ALL-ANGL BARRY B MOUNT ISOLATORS give vital in-flight reliability protection

Sure, you can meet the *specification* with a mount that only has to work at a 10-degree tilt. But what happens when the aircraft climbs at steep angles or goes into a 90-degree turn or dive?

That's where you need ALL-ANGL Barrymount® Isolators. You can mount 'em and *fly 'em* at any cock-eyed angle you choose. And they give the same sure protection to vital instruments and controls from take-off through every twist, turn, and dive of the aircraft's most violent maneuvers. These curves show why.





Write now for data sheets AA-0-1 containing detailed performance data. And remember — when your problem is protection thru every flight attitude, your answer is ALL-ANGL Barry Mounts. For recommendations, call your nearest Barry Sales Representative.

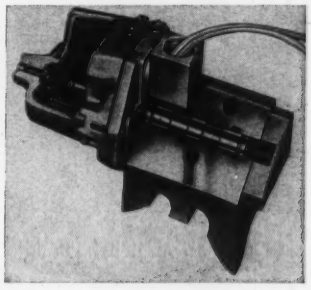
BARRY CONTROLS INCORPORATED

BARRY B MOUNT SALES REPRESENTATIVES IN ALL PRINCIPAL CITIES

722 PLEASANT STREET, WATERTOWN 72, MASSACHUSETTS

—ITEM 648—

New Parts



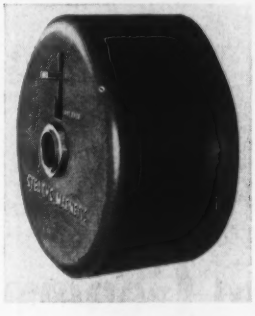
single-solenoid, spring return; double-solenoid, momentary; and double-solenoid, three-position. When ports are plugged, the basic four-way valve can be used for straight-way or three-way functions. Time of valve cycle is 0.033 sec, and flow capacity is equal to that of a ¼-in. diam hole. The unit measures 7¼ x 3½ x 3⅞ in. **Ross Operating Valve Co.**, 120 E. Golden Gate Ave., Detroit, Mich.

—Circle ITEM 474

Magnetic Brake

is solenoid-operated

Motor shaft in the HT-50 through-shaft magnetic disk brake extends through the center and out beyond the end of the brake to permit drive connection to both ends of the shaft. Incorporating solenoid



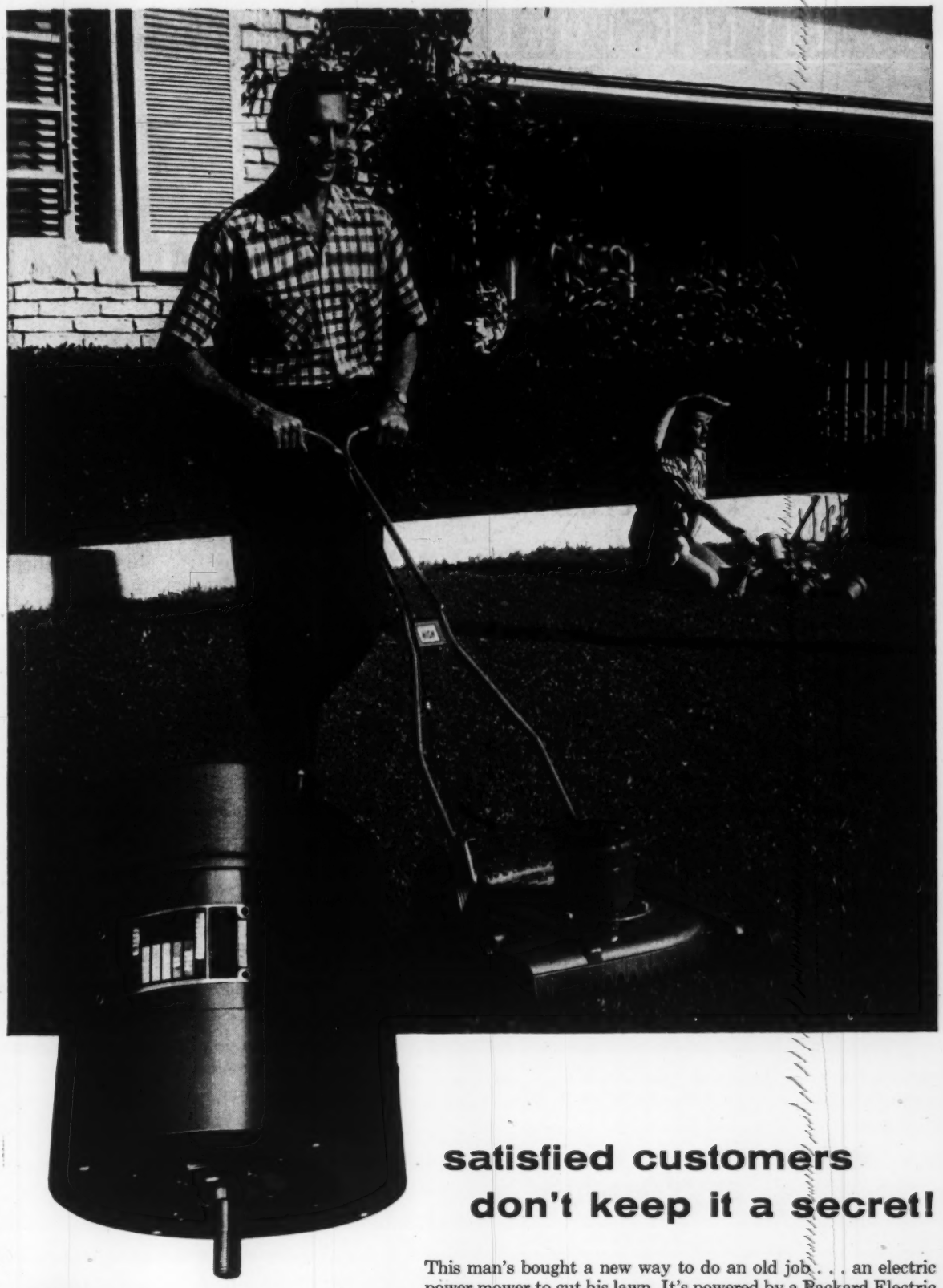
operation, the brake can be mounted on NEMA frames 56-C, 66-C, 182 and 184. **Stearns Magnetic Inc.**, 635 S. 28th St., Milwaukee 46, Wis.

—Circle ITEM 475

Needle Valves

have straight or angle patterns

Steel-bodied, bar-stock needle valves for general applications are available in sizes from ⅛ to ½-in., with either O-ring seals or conven-



satisfied customers don't keep it a secret!

This man's bought a new way to do an old job . . . an electric power mower to cut his lawn. It's powered by a Packard Electric motor, in fact, and he's letting his neighbor in on its smooth, quiet, dependable performance. No, there's no secret here.

There seldom is when an appliance is Packard-powered!

Packard Electric is an old hand at building satisfaction into motors. For over 39 years, Packard fractional horsepower electric motors have been delivering the kind of performance that makes for scenes like this. And scenes like this can't miss building sales and goodwill for appliance manufacturers.

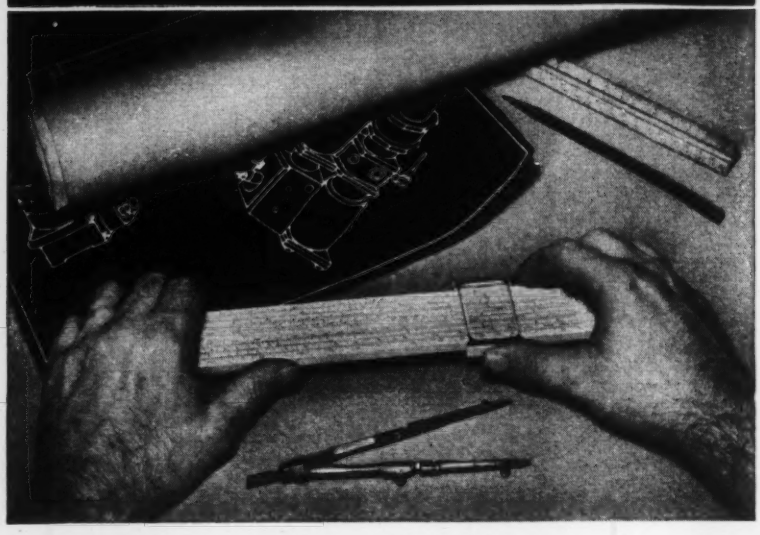
GM GENERAL MOTORS Packard

REG. U.S. PAT. OFF. TRADE MARK

Packard Electric Division
General Motors, Warren, Ohio

—ITEM 649—

FILTER FORUM



Question:

What facts should a product designer determine before choosing a filter?

Success of any pre-planned filter installation is dependent on calculations which are fundamental to the special field of filter design. As a rule, the data is simple to determine. Where unusual conditions exist, Purolator will design special filters to handle them.

Answer:

These five facts: 1. Degree of filtration, 2. Flow rate, 3. Contamination to be removed, 4. Viscosity of fluid, 5. Provision for cleaning or replacement.

1. Degree of filtration of a filter medium means the size of the smallest particles filtered out with 98% efficiency—expressed in microns for sizes less than .001 inch.

2. Flow rate is the flow that a clean filter unit will handle calculated in terms of the fluid's viscosity and the allowable pressure drop through the filter.

3. Contaminants are any elements from water to dust that shouldn't be there—the materials themselves, their quantity, their size.

4. As a rule, the pressure drop through a filter for a given flow rate is proportional to its viscosity.

5. Provision for cleaning or replacement depends on the predicted effects of a temporary lack of filtration while the cleaning or replacement is accomplished. Can the equipment operate temporarily without filtration, for example, can it be shut down periodically – or will two filters be needed; one for cleaning, one for service.

MAIL COUPON FOR DESIGN INFORMATION

PUROLATOR

FIRST in the field of filtering

Dept. D11-48, Purolator Products, Inc., 970 New Brunswick Ave., Rahway, N. J.

Please send me the following filter information:

_____ Purolator's new "Filtration Manual for Designers". I'm enclosing 25¢ to cover postage and handling.

_____ Enclosed is a description of our filter problem. How should we solve it?

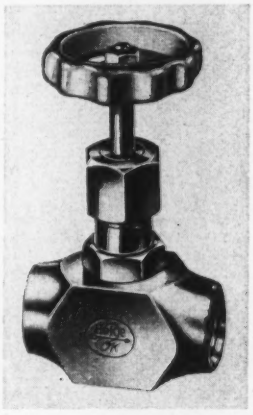
NAME_____ TITLE_____

COMPANY_____ ADDRESS_____

CITY_____ ZONE_____ STATE_____

—ITEM 650—

New Parts



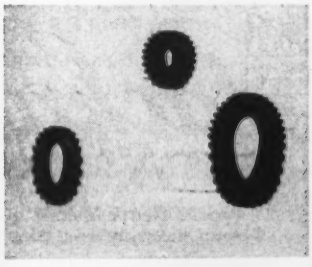
tional packing. O-ring style is especially applicable for high-pressure air or hydraulic service, and can be used for high vacuum service if helium leak tested. No packing adjustments are required on the O-ring type, and back seating permits repacking under pressure. Selfaligning spindle insures tight seating. Bar stock valves with carbon-steel bonnets and stainless-steel bodies are available for high temperature applications up to 750 F. Other materials used include brass and 430 F stainless steel. The valves are also available for direct instrument panel mounting, with black plastic handwheel. **Hoke Inc.**, 191 S. Dean St., Englewood, N. J.

—Circle ITEM 476

Spur Gears

are die-formed from iron powder

AGMA commercial-class 4 and precision-class 1 spur gears with cross-section to 1 sq in., are of pure electrolytic iron powder. Through high compacting pressures and carburizing, the powder duplicates the physical properties of most production steels. Tooth surface finish is equivalent to a ground finish, providing quiet



OHMITE®

AMRECON® *Relays*

HIGH QUALITY, ALL-PURPOSE RELAYS... RUGGED, DEPENDABLE FOR LONG LIFE!

65 types in four stock models

Ohmite Amrecon relays have proven their exceptional ruggedness and long life in years of service. Now, four popular stock models—DOS, DOSY, DO, and CRU, in 65 different types—are available from stock.

Models DO and DOS fill many industrial needs for a compact, lightweight relay that handles power loads usually requiring much larger, heavier units. They are particularly adaptable to aircraft and mobile equipment where severe shock and vibration are encountered. The increased operating sensitivity of Model DOSY relay, equipped with twin coils, makes the DOSY adaptable to a wide range of electronic control circuits, such as plate circuit controls. At 115 VAC or 32 VDC, noninductive load, Models DOS and DOSY have contact ratings of 15 amp; Model DO, 10 amp; and Model CRU, 5 amp. Available in a wide range of coil operating voltages and contact combinations.

Current ratings up to 25 amp, AC or DC. Also made-to-order models in many contact combinations and coil voltages.

HERMETICALLY SEALED OR DUST-PROTECTIVE ENCLOSURES

Be Right with

OHMITE®

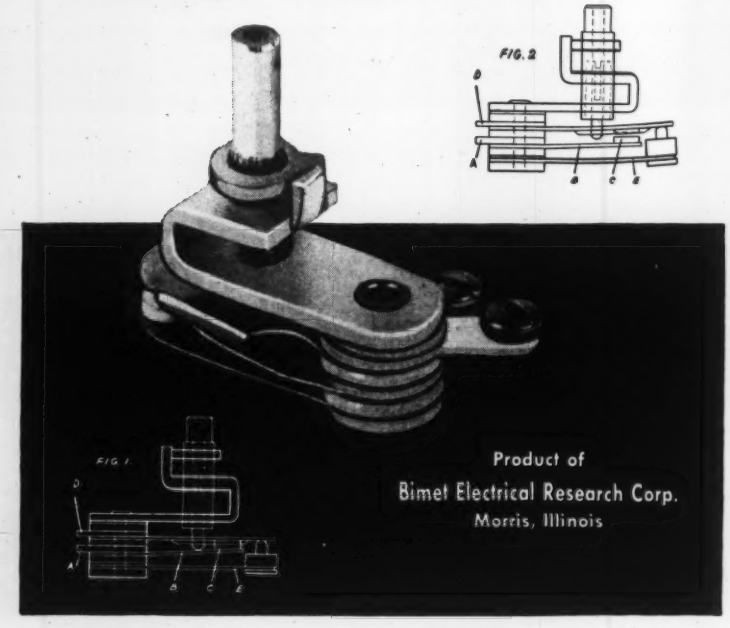
RHEOSTATS • RESISTORS • RELAYS • TAP SWITCHES

SEND FOR CATALOG R-10

OHMITE MANUFACTURING COMPANY
3618 Howard Street, Skokie, Illinois
(Suburb of Chicago)

How Chace Thermostatic Bimetal actuates the

Belcor Thermostat



Belcor Thermostats are precision-made, custom-built at costs comparable with stock thermostats. Features of these thermostats include: elimination of false cycling and "chatter" of contact points by virtue of passing current through the independent contact springs rather than the bimetal member; although pre-calibrated, a trim screw inside the adjusting shaft simplifies re-adjustment or re-calibration; single stud mounting gives fast transfer of heat and a single through-hole facilitates assembly.

Operating temperatures available up to 600 degrees F. UL approved, these thermostats include open and fully closed types. Contact ratings afford a variance to a maximum of 1500 watts at 120-240 V. AC.

How it works: In the normally closed circuit position (Fig. 1), current passes from terminal (A) through stainless steel spring (B) and silver contacts (C) back to terminal (D). Ambient temperatures in excess of the factory calibrated rating cause the Chace Thermostatic Bimetal strip (E) to deflect (Fig. 2), opening the circuit at contacts (C) until temperature is again normalized.

Chace Thermostatic Bimetal is available in 29 types, in strip, coil or in complete elements made to customer specification. Write now for our free 36-page booklet, "Successful Applications of Chace Thermostatic Bimetal."

IT BENDS WITH THE HEAT

W. M. CHACE CO.
Thermostatic Bimetal
1616 BEARD AVE., DETROIT 9, MICH.

—ITEM 652—

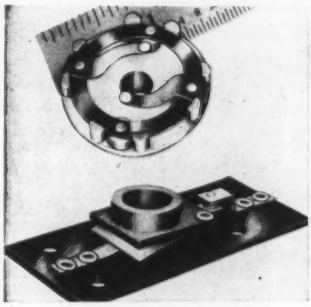
operation. Gears are made to specific requirements. **Globe Industries Inc.**, Supermet Div., 1466 Cincinnati St., Dayton 8, O.

—Circle ITEM 477

Centrifugal Switch

for electronic-equipment cooling blowers

Overheating of electronic equipment due to failure of the cooling system is prevented by this miniature centrifugal switch. Developed as a protective device for



business machines and computers, the switch is mounted on the output side of the cooling-blower shaft. If blower speed should fall below a predetermined minimum, the switch cuts out all equipment in the electronic circuit. Accuracy of speed setting is 0.25 per cent and operating life is at least 1 million cycles. Diameter of unit is 1 1/16 in. **Torq Engineering Products Inc.**, Interstate St., Bedford, O.

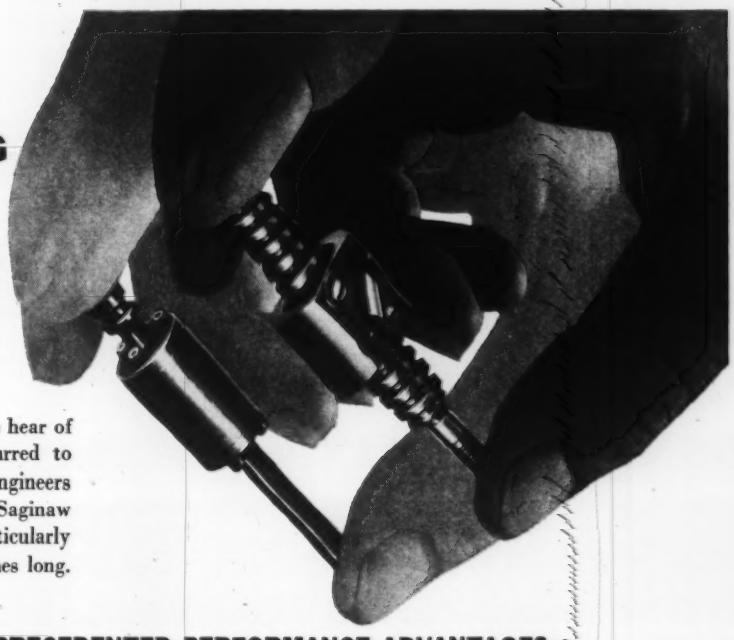
—Circle ITEM 478

Asbestos Fabric

contains no metallic particles

Series of friction materials of woven asbestos fiber impregnated with oils and resins has been developed for oil-cooled power transmission equipment. The material, which is nonmetallic and lighter than metallic friction disks, sustains normal pressures met in the equipment. Flexibility in use is achieved by varying weave, impregnating ingredients and processing treatment. The fabric can be bonded to metal plates with thermosetting resins and assembled in oil-cooled units alternately

HOW MANY POSITIONING PROBLEMS CAN THESE AMAZING UNITS SOLVE FOR YOU?



Frankly, we don't know. Almost daily we hear of some new application that never occurred to us. But we do know this: electronics engineers are achieving the "impossible" with Saginaw ball/bearing Screws and Splines, particularly these miniature sizes, from 1½ to 3 inches long.

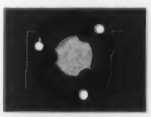
CHECK THESE UNPRECEDENTED PERFORMANCE ADVANTAGES:

Saginaw ball/bearing SCREWS

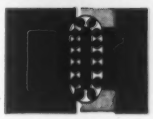
Nut *glides* on steel balls. Like stripes on a barber pole, the balls travel toward end of nut through spiral "tunnel" formed by concave threads in both screw and mating nut.

At end of trip, one or more tubular guides lead balls diagonally back across outside of nut to starting point, forming closed circuit through which balls recirculate.

Saginaw ball/bearing SPLINES



The *Saginaw b/b Spline* radically increases the efficiency of transmitting or restraining high torque loads. Instead of *sliding* against each other, the mating surfaces *glide* on rolling balls.



The steel balls recirculate in closed circuits formed by mating longitudinal raceways spaced around the circumference of both inner and outer splines. Guides return balls to starting point.

UP TO 5 TIMES MORE EFFICIENT

Up to 95% efficiency guaranteed in transforming rotary to linear motion; over 80% efficiency, linear to rotary. Require less than 1/5 as much torque as conventional Acme screws for equal output.

SAVE SPACE, WEIGHT, POWER

Permit much smaller, lighter motors and auxiliary equipment. Saginaw b/b Screws have been built from 1½ inches to 39½ feet in length.

PRECISE POSITIONING AND SYNCHRONIZING

Machine-ground types provide precision control within fractional thousandths of an inch, plus perfect synchronization of two or more movements.

OPERATE IN VERY ADVERSE ENVIRONMENTS

Saginaw b/b Screws have been designed and built to operate from −75° to +900° F. Even if lubrication fails or cannot be originally provided, they will still function with remarkable efficiency.

LONG, DEPENDABLE SERVICE LIFE

Accurately predictable life engineered to design requirements. Special Gothic arch groove design and multiple circuits assure dependable performance.

40 TIMES LOWER FRICTION COEFFICIENT THAN ORDINARY SLIDING SPLINES

By applying the same basic gliding ball principle pioneered by Saginaw in the ball/bearing screw, this revolutionary new kind of spline makes practical new engineering designs never before possible.

TRANSMIT OR RESTRAIN HIGH TORQUE LOADS FAR MORE EFFICIENTLY

In any application where column length must change under torque load, the Saginaw b/b Spline offers unprecedented freedom from sliding spline restrictions.

WIDE CHOICE OF ATTACHMENTS

Can be fitted with integral gears, clutch dogs, bearing and sprocket seats or other attachments for use with electric, hydraulic or pneumatic units.

WIDE RANGE OF SIZES AND TYPES

Saginaw b/b Splines have been designed from 3 inches to 9 feet in length, and from ⅜ to 3¾ inches in diameter. To convert push-pull to rotary motion, helical types are available with very high leads, ranging from 20:1 to 100:1.

Saginaw

ball bearing Screws & Splines

MAIL COUPON TODAY FOR NEW ENGINEERING DATA BOOK

Saginaw Steering Gear Division
Ball Bearing Screw & Spline Operation
General Motors Corporation
Dept. 4H, Saginaw, Michigan
Please send your Engineering Data Book to:

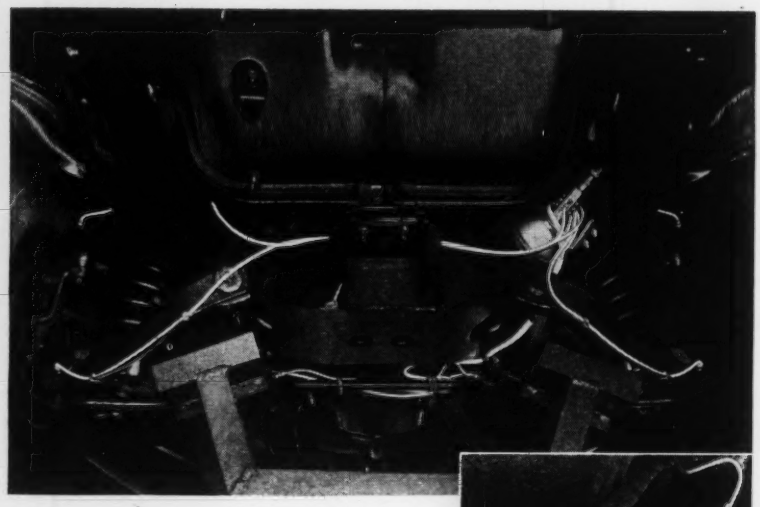
Name—Title_____

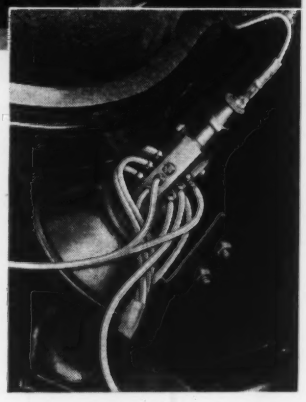
Firm_____

Address_____

City_____ Zone____ State_____

—ITEM 653—





Why Lubrication Engineers Specify nylaflow® Tubing To Solve Hard-Service Installation Problems

• Push-button power lubrication systems like the installation shown above depend on NYLAFLOW pressure tubing for this tough service. For flexible NYLAFLOW, produced from specially processed nylon, has the characteristics required to make these systems desirable—cost-wise and performance-wise.

ALMOST UNLIMITED FLEX LIFE—The continuous flexing and vibration of automobile front wheel suspensions causes no fatigue in highly flexible NYLAFLOW.

HIGH STRENGTH—Few tubings can approach NYLAFLOW's high strength per weight ratio. NYLAFLOW, available in burst strengths of 1000 psi. and 2500 psi., is 1/2 the weight of aluminum, 1/9th the weight of copper.

CRUSH PROOF, DENT PROOF—NYLAFLOW's bone-like structure offers high resistance to accidental shock or impact.

CORROSION RESISTANT—NYLAFLOW is impervious to hydrocarbons and practically all solvents, including hydraulic fluids, alkalis and salt spray.

LOW INSTALLATION COST—NYLAFLOW requires no pre-bending for installation—bends easily and symmetrically to exact shapes required, needs no special fittings or flexible couplings, and is easily worked from light, compact coils.

NYLAFLOW is available in a variety of sizes and coil lengths. Write today for latest test and application data.

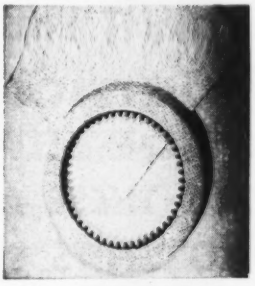
THE POLYMER CORPORATION of Penna. • Reading, Penna.
In Canada: Polypenco, Inc., 2052 St. Catherine St., W., Montreal, P.Q.

POLYPENCO Nylon, Teflon*, Q-200.5 and K-51

*DU PONT TRADEMARK

—ITEM 654—

New Parts



with metal pressure plates. Thickness is 0.030 to 0.090-in. in increments of 0.010-in. Single pieces, available with diameters up to 12 in. O.D., can be segmented to obtain larger diameters. Fabric is available in rings, bands and cores, either alone, cut to required size, or bonded to plates. **Thermoid Co.**, Friction Div., Whitehead Road, Trenton 9, N. J.

—Circle ITEM 479

Induction Motor

for business machines

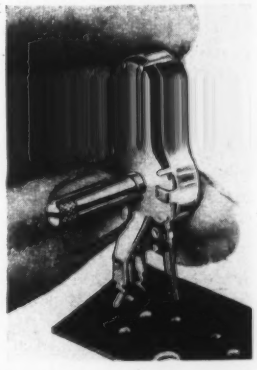
M49-frame, four-pole business machine motor, designed to meet new adding machine and typewriter specifications, is 5 in. long, 2.97 in. in diam and weighs 3¾ lb. Of permanent split-capacitor design, it has a resilient single-bonded ring mounting which provides quiet operation. Oil consumption is negligible. **General Electric Co.**, Specialty Component Motor Dept., One River Road, Schenectady 5, N. Y.

—Circle ITEM 480

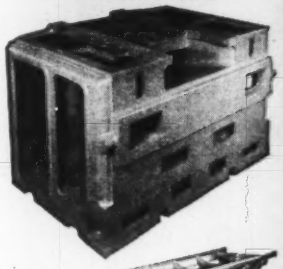
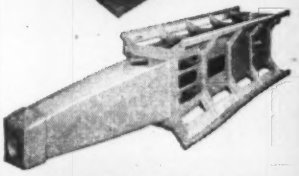
Variable Resistor

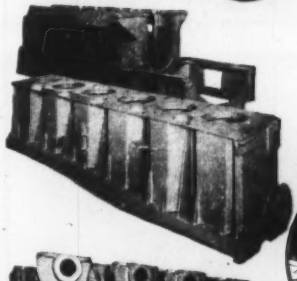
snaps into printed-circuit chassis boards

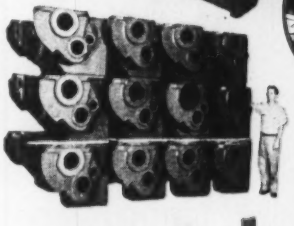
No mounting hardware is required for this variable LR-70 composition resistor. Four legs, three voltage taps and a case grounding leg,

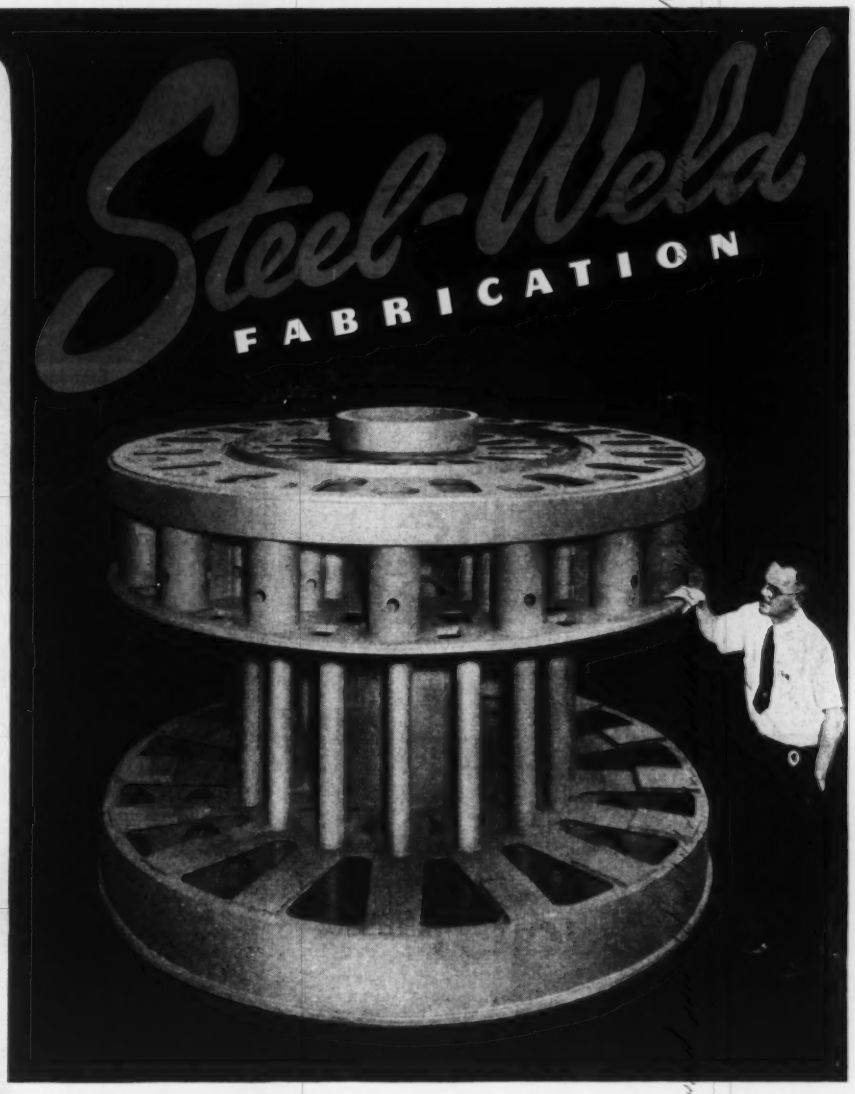


Steel-Weld FABRICATION







Use WELDED STEEL for Greater Strength with Less Weight!

Above you see one of four identical pieces recently produced and machined by Mahon. It is part of a machine designed for use in the manufacture of paper plates. This piece, and the parts and assemblies illustrated at the left, are typical of thousands of Steel-Weld Fabricated units produced and machined by Mahon for manufacturers of processing machinery, machine tools, and other types of heavy mechanical equipment. Are YOU making full use of welded steel components in your products? In some instances pattern cost and time are an important factor . . . in others the strength-weight ratio is important. In the design of almost any type of heavy machinery, there are pieces and sub-assemblies that lend themselves to more economical production in welded steel. If you build such machinery or equipment, you will be interested in Mahon's facilities to serve you . . . because, the Mahon organization is a unique source for welded steel in any form . . . a source with complete facilities for design engineering, fabricating, machining and assembling. See Sweet's Product Design File for information, or have a Mahon engineer call at your convenience.

THE R. C. MAHON COMPANY • Detroit 34, Michigan

Sales-Engineering Offices in Detroit, New York and Chicago

Engineers and Fabricators of Steel in Any Form for Any Purpose

MAHON

—ITEM 655—

For More Information Circle Item Number on Yellow Card—page 19

The Best

in stock

are the easiest

in stock

to get

in stock

mean faster deliveries from stock!

FOOTE BROS.
LINE-O-POWER SPEED REDUCERS

Standardized interchangeable gearing – by Foote Bros. – lets you specify and get the particular reducer you want, in the quantities you need, direct from stock! Duti-Rated Lifetime Gearing in a complete range of interchangeable sizes, ratios and capacities are stocked and ready for assembly. Capacities range up to 200 H. P., ratios to over 2700 to 1. Standard foot and flange type cast housings are stocked, too, for straight or right angle drives. The drives you want are assembled from stock components and shipped as soon as your order is received. For a complete index to the almost endless variety of Line-O-Power reducers immediately available, write for your copy of the Line-O-Power catalog today. See for yourself how you can get more for your drive dollar . . . faster!

This trademark stands for the finest industrial gearing made!

T. M. REG. U. S. PAT. OFF.

FOOTE BROS.

Better Power Transmission Through Better Gears

FOOTE BROS. GEAR AND MACHINE CORPORATION

4545 South Western Boulevard, Department. O, Chicago 9, Illinois

—ITEM 656—

For More Information Circle Item Number on Yellow Card—page 19

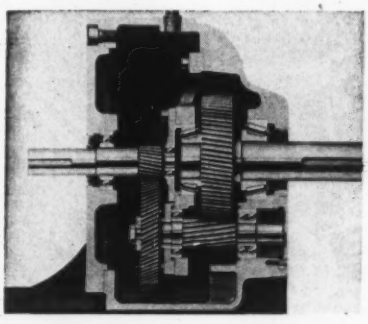
snap into a printed circuit wiring board to form a strong support. Gold-plated ring-spring and hub-spring contactors ensure smooth, quiet operation. Rated at 0.75 w for resistance values above 10,000 ohms and 0.50 w below 10,000 ohms, the resistor is intended for use in TV, FM, and other printed-circuit chassis where space and cost must be held to a minimum. **Stackpole Carbon Co.**, Electric Component Div., St. Marys, Pa.

—Circle ITEM 481

Helical Gear Drives

with double or triple reduction stages

In-line arrangement of input and output shafts in this heavy-duty



helical-gear speed reducer minimizes space requirements and simplifies layout problems. Unit is available with double-reduction ratios from 6.2 to 38.4:1 and capacities to 118 hp; triple-reduction ratios run from 47.1 through 292:1 with capacities to 20 hp. Housing is one-piece cast iron, and all moving parts are splash lubricated and permanently aligned. Speed ratio can be changed without removal of the low-gear set. **Link-Belt Co.**, 307 N. Michigan Ave., Chicago 1, Ill.

—Circle ITEM 482

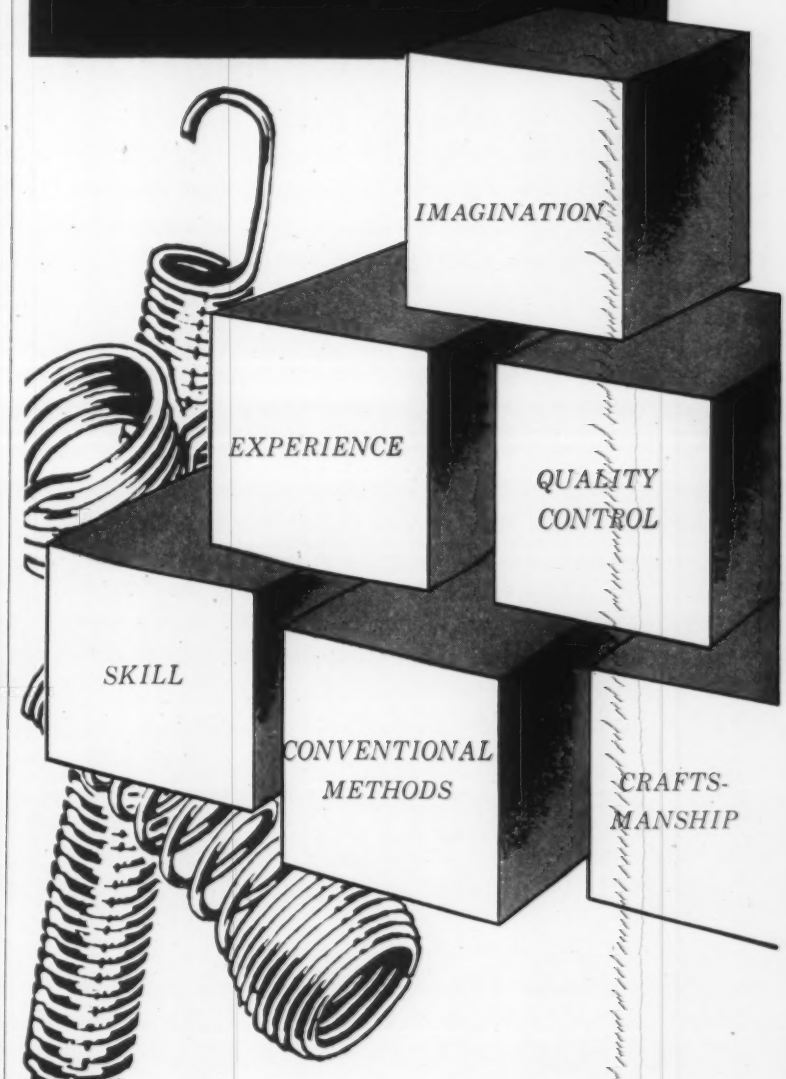
Nylon Tubing

has burst rating of 2500 psi

Flexible Nylaflow tubing conveys lubricants, water and plastic spray, and is also used for air lines. It has an outside diameter of ¼-in. with a wall of 0.050-in. and burst rating of 2500 psi. The tubing re-

(*Continued on Page* 182)

BUILDING BLOCKS
for Accurate Springs



Conventional, accepted standards of manufacturing springs are a building block at Accurate Springs. So are skill, craftsmanship, experience, quality control—*and imagination!* It all adds up to a better spring, at lower cost, held to closer tolerances—*for YOU.*

Accurate Springs

ACCURATE SPRING MFG. CO.
3824 West Lake Street
Chicago 24, Illinois

SPRINGS • WIREFORMS • STAMPINGS

DESIGN SOLUTIONS with G-E

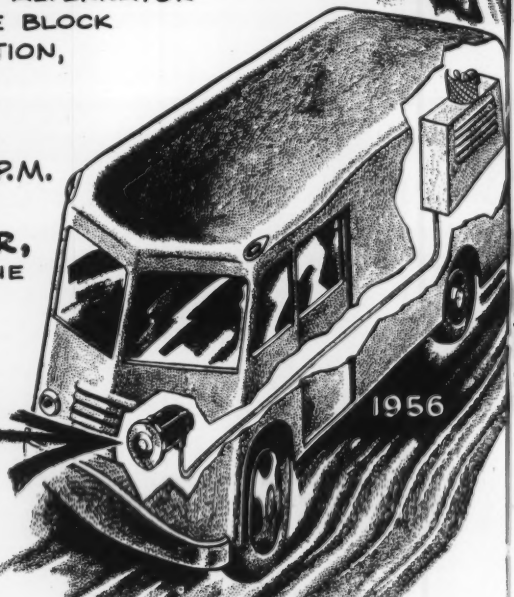
NOW SPECIAL G-E ALTERNATOR MAKES TRUCK REFRIGERATION ALL-ELECTRIC

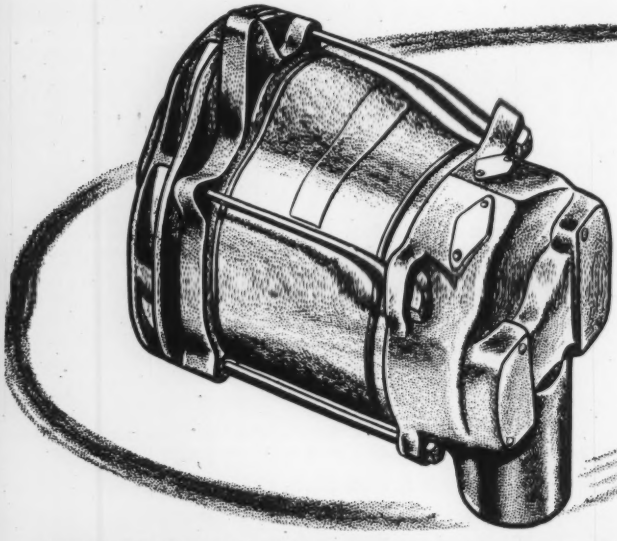
BUILT TO WITHSTAND HEAT, ROAD SHOCK, MOISTURE...

TO PROVIDE MILK AND OTHER TYPES OF DELIVERY TRUCKS WITH STAND-BY COOLING, MORE ROOM FOR PAYLOAD, DRY COLD, AND MANY OTHER BENEFITS, G.E. HAS DESIGNED A SET OF ELECTRICAL COMPONENTS THAT NOW MAKE POSSIBLE **NEW ALL-ELECTRIC TRUCK REFRIGERATION.**

THE STURDY AND WEATHER-RESISTANT G-E ALTERNATOR IS DESIGNED TO BE MOUNTED ON THE ENGINE BLOCK WHERE IT MUST WITHSTAND CONTINUOUS VIBRATION, ROAD SHOCK, DUST, HEAT FROM THE ENGINE. SPECIAL ELECTRICAL CHARACTERISTICS OF THE ALTERNATOR INCLUDE WIDE RANGE OF OPERATING SPEEDS - FROM 1500 TO 10,500 R.P.M.

A SELENIUM RECTIFIER, VOLTAGE REGULATOR, COMPRESSOR DRIVE MOTOR, EVAPORATOR FAN MOTOR-OPERATE WITH THE ALTERNATOR TO MAKE UP POWER SUPPLY FOR THIS NEW METHOD OF TRUCK REFRIGERATION.





NEW DEVICE CHECKS ON BAD CHECKS

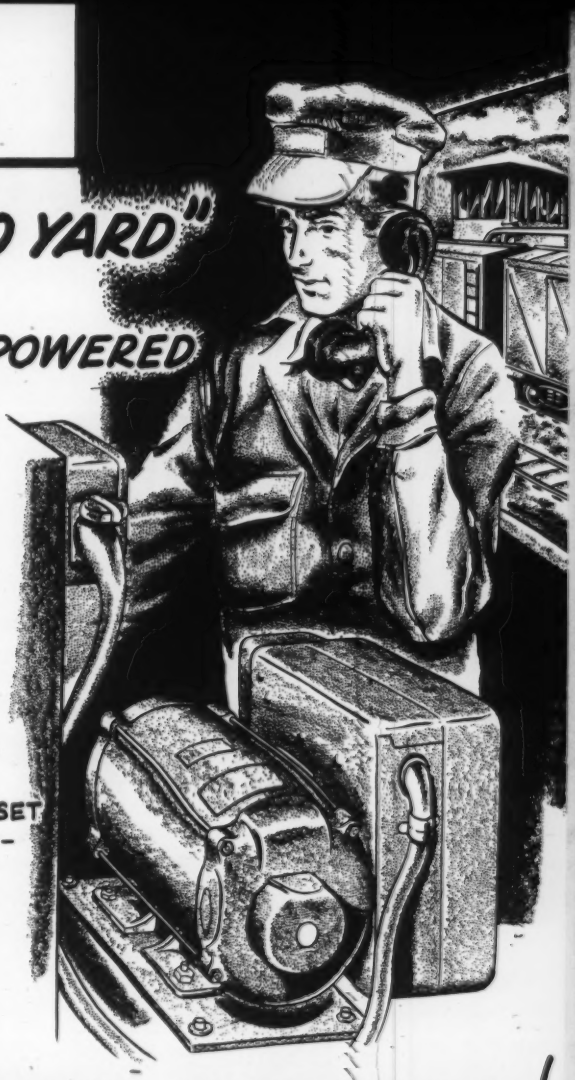
POWERED BY EXCLUSIVE LOW-SPEED G-E A-C MOTOR

G-E SYNCHRONOUS INDUCTOR 75 R.P.M. MOTOR-EQUIPPED WITH SPECIAL OPEN-SPUR GEARING BY CUSTOMER - CAN OPERATE UNDER 10 R.P.M. PERMITS INSTANT STOPS AND STARTS ON AUTOMATIC BAD CHECK DETECTOR DEVICE. THE MOTOR OPERATES A CAMERA DRIVE - TRIPS THE SHUTTER AND WINDS FILM. MACHINE RECORDS ON A SINGLE 35 MM FRAME OF FILM A PHOTOGRAPHIC LIKENESS OF EACH CHECK AND OF THE PERSON WHO WROTE IT.

specialty motors

"LOCOMOTIVE TO YARD"

RAILROADS NOW DEPEND ON TELEPHONE COMMUNICATIONS POWERED BY G-E MOTOR ALTERNATOR



G-E MOTOR ALTERNATOR SETS FOR RAILWAY COMMUNICATIONS MUST DELIVER EXTRA—RELIABLE PERFORMANCE, AND AT THE SAME TIME STAND UP AGAINST THE ABUSE OF RAILROAD VIBRATIONS, AND ALL-WEATHER CONDITIONS. THE SPECIALLY-DESIGNED ALTERNATOR, ENCASED IN A RUGGED HOUSING, NOW PERMITS INSTANT CONTACT BETWEEN YARD AND TRAIN, OR BETWEEN LOCOMOTIVE AND CABOOSE. BOTH OPEN, AND EXTRA-STURDY TOTALLY-ENCLOSED SETS ARE AVAILABLE. EITHER SET SUPPLIES 115-VOLT, 60 CYCLE CURRENT TO RADIO-TELEPHONE EQUIPMENT, PROVIDING SUITABLE POWER FOR A SINGLE RECEIVER, AND ONE 10-TO 30-WATT TRANSMITTER. A SPECIAL FEATURE, A BUILT-IN THERMAL OVERLOAD DEVICE, PROTECTS AGAINST EXTERNAL LINE FAILURES.

AVAILABLE: COMPLETE FHP MOTOR ENGINEERING ASSISTANCE FOR YOU!

HERE'S THE SPECIAL ATTENTION YOUR SMALL MOTOR PROBLEMS GET AT G. E.

1 YOUR LOCAL G-E APPARATUS SALES ENGINEER LEARNS ALL ABOUT YOUR MOTOR NEEDS

2 HE CALLS A TEAM OF FACTORY ENGINEERS WITH YEARS OF MOTOR APPLICATION EXPERIENCE

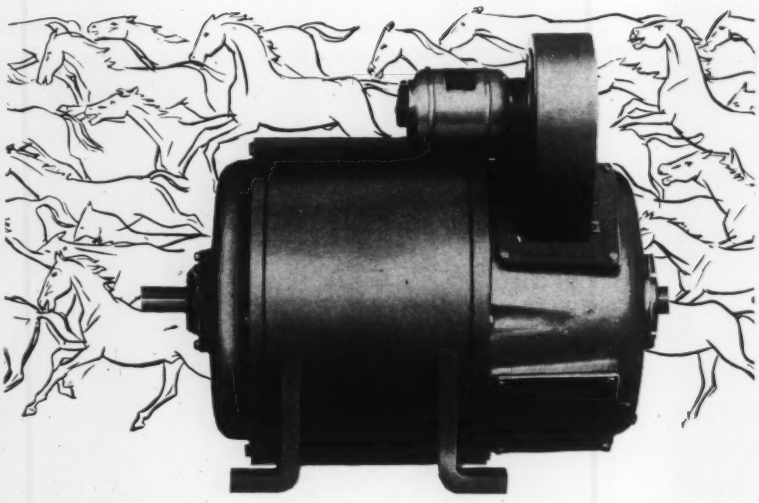
3 AT THEIR DISPOSAL ARE G.E.'S COMPLETE DEVELOPMENT AND TESTING FACILITIES

4 IN SHORT ORDER A SAMPLE G-E MOTOR IS READY FOR TESTING ON YOUR PRODUCTS

FOR THIS COMPLETE HELP, CONTACT YOUR NEARBY G-E APPARATUS SALES OFFICE, TODAY. WRITE FOR FREE BULLETINS COVERING G-E EQUIPMENT DESCRIBED IN THIS AD TO GENERAL ELECTRIC CO., SECT. 634-6, SCHENECTADY 5, N.Y.

GENERAL ELECTRIC

SPECIAL



five equals fifty

This DC motor is actually ten times the motor it appears to be. It is the size of a 5-h.p. motor, but it's rated 50 h.p. short-duty, and over 20 h.p. continuous.

In designing this particular shunt-wound motor, high power in a small space was the major consideration, but not the only one. It also had to accelerate to 6000 r.p.m. within one second and withstand frequent, fast reversals without excessive overheating. Physically, this small-scale giant measures just 16″ long by 9½″ dia., and weighs only 115 lbs.

Admittedly, this is a special motor. It is also typical of ESCO's unusual ability to design and build all kinds of special rotary equipment to meet particular needs. For over forty years ESCO has been pleasing its customers by finding answers that exactly match special requirements. Perhaps our solution to your particular motor problem will please you, too.

Refer to Esco Catalog in section 4a/E1 in Sweet's Product Design File, or write direct for general catalog No. 56PD. Why not also send us details on your special problem — we'll be glad to show you how we would go about solving it for you.

ESCO ELECTRIC SPECIALTY CO.
179 South Street, Stamford, Conn.

—ITEM 659—

New Parts

(*Continued from Page* 179)

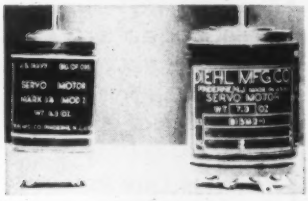
sists abrasion and impact, is impervious to oil, greases, gasoline and hydraulic fluids, and is unaffected by alkalis and solvents. It is best suited for long term use below 180 F, although retaining its shape and much of its strength at temperatures to 475 F. **Polymer Corp. of Pennsylvania,** 125 N. Fourth St., Reading, Pa.

—Circle ITEM 483

Miniature Servo Motors

for industrial use

Designed as low-cost units for industrial applications, these miniature induction servo motors have high torque-to-inertia ratios. Mini-



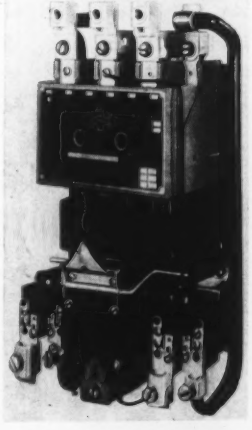
mum locked torque of size 11, six-pole motor (left) is 0.63-oz.-in.; size 15, eight-pole motor (right) has 1.5 oz-in. locked torque. Control phases may be supplied for 115 and 230-v series connection, or 57.5 and 115-v parallel connection. Motor shafts are either plain round or splined. **Diehl Mfg. Co.,** Somerville, N. J.

—Circle ITEM 484

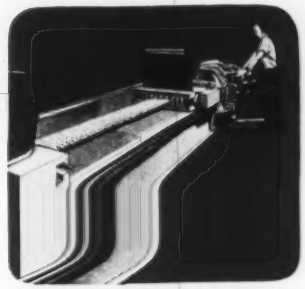
Magnetic Starter

has dual-purpose coils for 220 and 440-v lines

Magnetic starter and contactor (size 4) has dual-voltage coils that



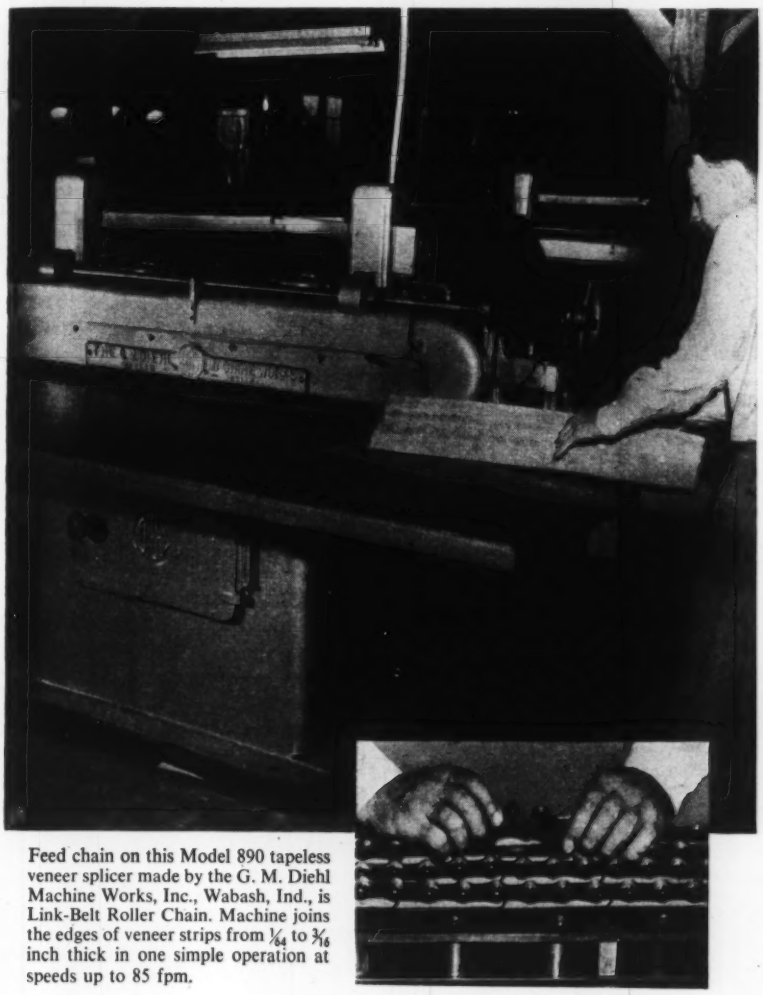
LOCK-TYPE BUSHINGS (applied on a range of sizes) end a common cause of stiff chain.



PRE-STRESSING of multiple width chain provides uniform load distribution.

SHOT-PEENED ROLLERS have greater fatigue life, added ability to withstand impact.

How these LINK-BELT EXTRAS make roller chains last longer



Feed chain on this Model 890 tapeless veneer splicer made by the G. M. Diehl Machine Works, Inc., Wabash, Ind., is Link-Belt Roller Chain. Machine joins the edges of veneer strips from 1/64 to 3/16 inch thick in one simple operation at speeds up to 85 fpm.

THERE's more to roller chain than just the parts you see. *Much more!* There are the hidden extras—standard on Link-Belt Precision Steel Roller Chain—that add up to longer life and lower costs.

Throughout every stage of manufacture, Link-Belt takes *extra* care to build *extra* life into Precision Steel Roller Chain. Shown above are three of these added refinements . . . and there are many others which contribute to better performance and longer life for your machines.

There's complete application information on roller chains in 148-page Data Book 2457. Ask your nearby Link-Belt office for your copy.

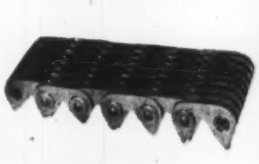
You can choose from a wide range of Link-Belt roller chains and sprockets. In addition, Link-Belt's complete line includes silent chain drives . . . and all sizes and types of cast, combination, forged and fabricated steel chains.

LINK-BELT

CHAINS and SPROCKETS

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office: New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World. 14,039

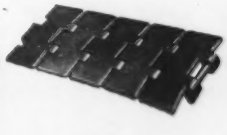
No one chain serves every purpose . . . get the RIGHT one from Link-Belt's complete line



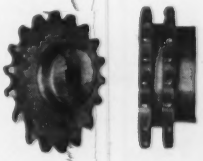
Silent Chain

LXS Steel Chain

Detachable Steel Link-Belt

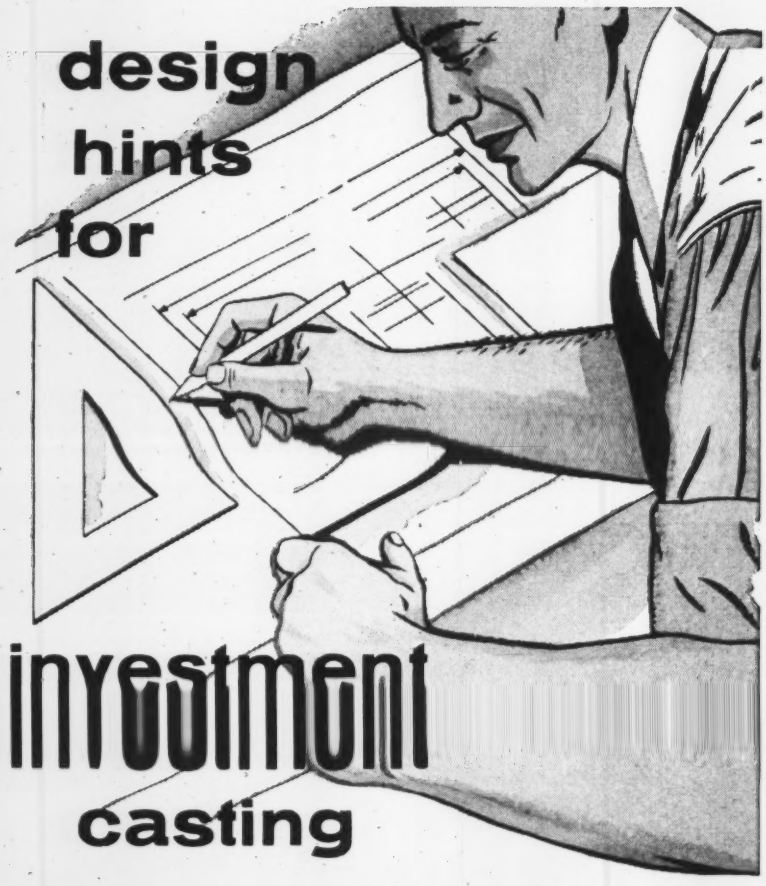


S-815 Flat-Top Chain



Cast and Cut-Tooth Sprockets

—ITEM 660—

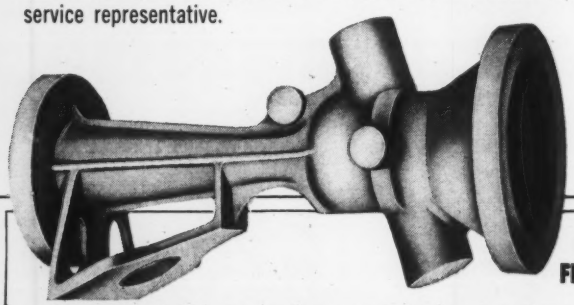


DESIGN PARTS FOR THE SHAPE YOU WANT—Investment Casting can produce the most intricately shaped parts with little or no secondary machining required.

CHOOSE THE ALLOY YOU WANT—Investment Castings are produced in any of the ferrous or non-ferrous alloys, including magnesium.

USE THE PROCESS WISELY—Give full consideration to weight, dimensions, tolerances and surface finishes when designing for Investment Casting. Take full advantage of the economies inherent in the process.

CONSULT ARWOOD ENGINEERS—Arwood casting engineers will gladly consult with you on your design and production problems, helping you translate them into finished products. Write for the name of your nearest ARWOOD sales and service representative.



DESIGN FLEXIBILITY

Parts similar to this stainless steel valve body for an air flow controller often require several changes before design is finalized. Due to the relatively low cost of dies and die changes, the investment casting process has proven an inexpensive and flexible method.

ARWOOD

ARWOOD PRECISION CASTING CORP.

78 Washington Street, Brooklyn 1, New York

Plants: Brooklyn, N. Y. • Groton, Conn • Tilton, N. H. • Los Angeles, Calif.

"PIONEERS IN INVESTMENT CASTING"

—ITEM 661—

New Parts

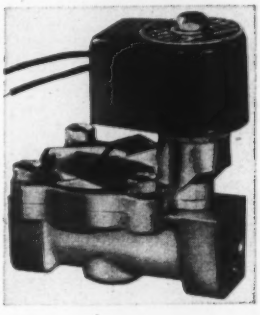
are easily connected for either 220 or 440-v lines. Contacts are silver-cadmium oxide and arc box is plaskon alkyd, which is arc, fire and age resistant. Compact in design, the new size 4 is only slightly larger than size 3 controllers. Non-current carrying parts, such as magnet assembly, arc box, cross arm and mounting plates are the same as used in size 3. **Furnas Electric Co.**, 1000 McKee St., Batavia, Ill.

—Circle ITEM 485

Solenoid Valve

uses no packing

Stuffing boxes and sliding glands are eliminated by packless construction of this ¼-in. general-purpose solenoid valve. Available



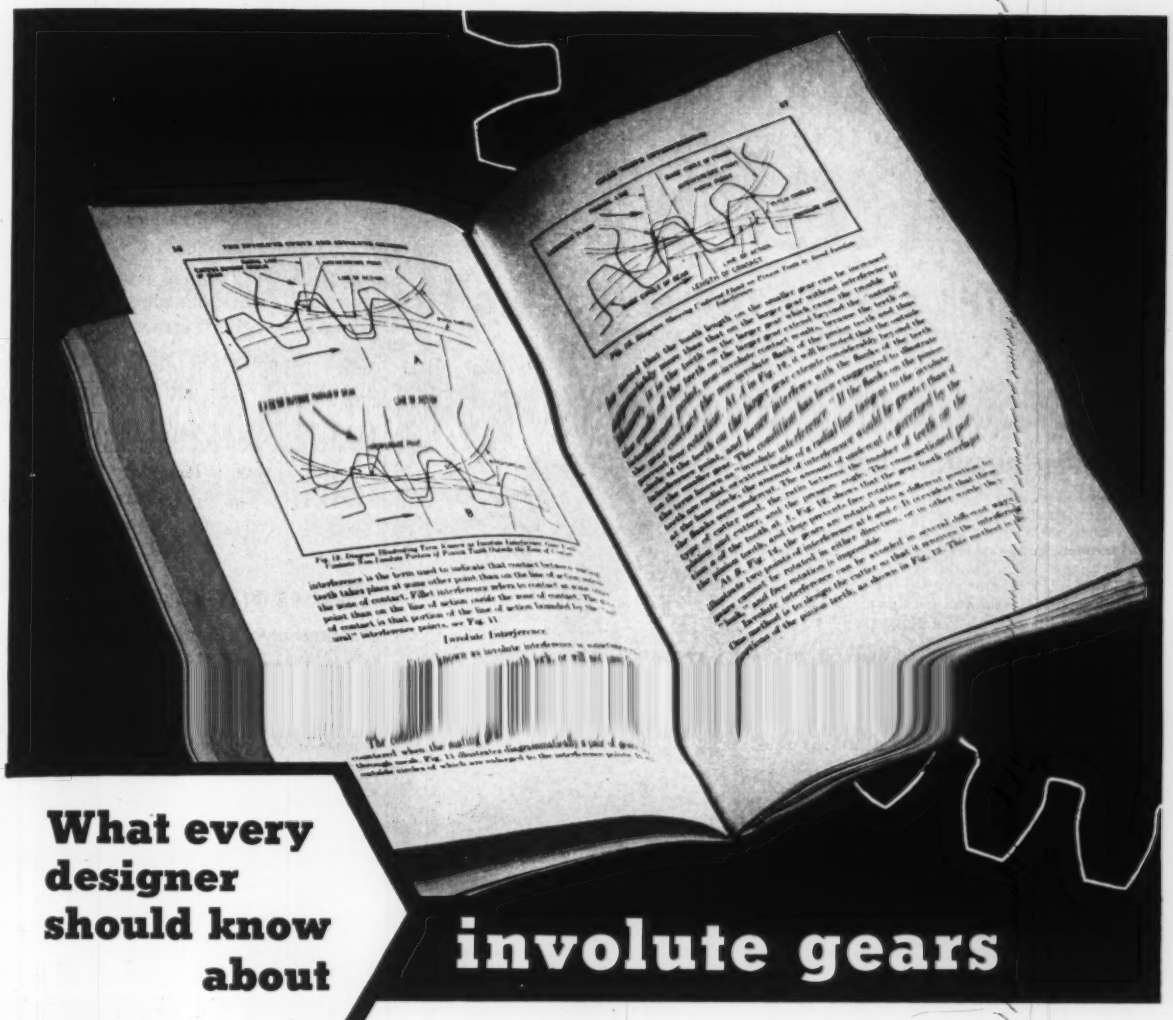
in normally-open and normally-closed models, it can be mounted in any position. Solenoid coils are Class A continuous duty and require 10.5-w ac or 10-w dc for operation. Enclosures are either pressed-steel, watertight, or explosion-proof construction. **Automatic Switch Co.**, 391 Lakeside Ave., Orange, N. J.

—Circle ITEM 486

Fractional-HP Motor

has improved 24-slot lamination design

Model 2900 induction motor, rated 1/100 to 1/15 hp, has higher power-to-weight ratio than former model. Improved cooling and lower power consumption ensure long bearing life, minimum lubrication troubles and permit operation at higher ambient temperatures. Because motor laminations are now 24-slot design instead of 16 slot,



What every designer should know about involute gears

The properties of the involute curve as a gear-tooth profile offer many possibilities in the design of gears. To take full advantage of them, you must know the three basic elements of gear design and the fundamental laws of the involute curve.

These are stated in "The Involute Curve and Involute Gearing," a complete treatise on Involute Gear Design. The contents of this booklet also include such useful subjects as the function of gearing, the application of the involute to gear teeth, the Gear Shaper Cutter, generating involute gears on the Fellows Gear Shaper, checking profiles on Fellows Involute Measuring Instruments and definitions of gear tooth elements. A copy is yours for the asking. Just write any Fellows Office.

You should also know that in addition to providing speed and accuracy in generating involute gears, the Fellows Gear Shaper provides an economical means for generating many non-involute shapes such as sprockets, cams and other irregular contours.

THE FELLOWS GEAR SHAPER COMPANY
78 River Street, Springfield, Vermont
Branch Offices: 319 Fisher Building, Detroit 2
5835 West North Avenue, Chicago 39
2206 Empire State Building, New York 1
6214 West Manchester Avenue, Los Angeles 45

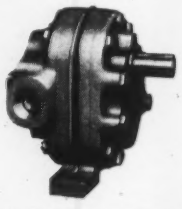
THE PRECISION LINE **Fellows** *Gear Production Equipment*

GOT A PUMPING PROBLEM?

PERHAPS THE ANSWER YOU'RE LOOKING FOR IS A ROPER ROTARY PUMP

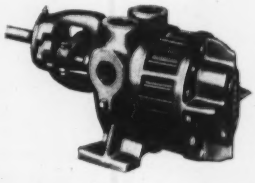
ROPER PUMP-MOTORS

These units offer low-speed and high-torque, and their versatility finds them well-suited to heavy-duty service within their operating range. In general, recommended speed is 200 to 800 R.P.M. with pressures to 800 P.S.I. In this range, they require from 7 to 40 G.P.M. flow and will develop up to 11.5 H.P. output at maximum speed and pressure.



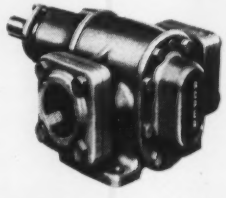
ROPER SERIES F PUMPS

Among the dependable Ropers is the Series F Pump — pressures to 300 P.S.I., sizes 1 to 300 G.P.M. It features four-port design with 8 optional piping arrangements . . . supplied in standard fitted models. With packed box or mechanical seal; with or without relief valve.



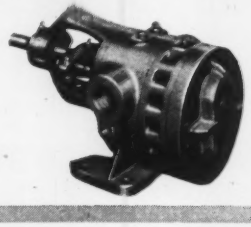
ROPER SERIES K PUMPS

Operate your hydraulic circuit with the correct size Roper for the particular job. In many cases the Series K will do, for it is rated from pressures to 150 P.S.I., capacities ¾ to 50 G.P.M. This model is compact, sturdy . . . is self-lubricated by liquid pumped. Comes with packed box or mechanical seal . . . with or without relief valve.



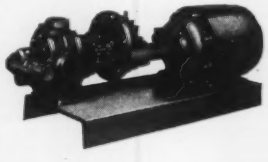
ROPER SERIES H PUMPS

Lower maintenance costs with a Roper. For instance, a pump like the Series H with pressures to 1000 P.S.I., sizes 10 to 75 G.P.M. is ideally suited for hydraulic mechanisms and for other applications requiring high pressures. Spur gears run in axial hydraulic balance . . . roller bearings and bronze wear plates reduce friction. Available with packed box or mechanical seal.



ROPER SERIES 3600 PUMPS

You'll profit more with dependable Roper Series 3600 Pumps on the job . . . they are speedy, quiet, and plenty rugged. Service-proved features such as self-lubrication, adjustable relief valve, hardened gears, and mechanical seal contribute to Roper dependability. Sizes range from 40 to 300 G.P.M.; pressures to 60 P.S.I.



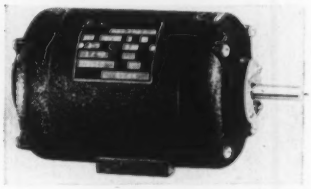
GEO. D. ROPER CORP. 244 BLACKHAWK PARK AVE., ROCKFORD, ILL.

SEND NOW FOR DESCRIPTIVE BULLETINS

ROPER Rotary Pumps

—ITEM 663—

New Parts



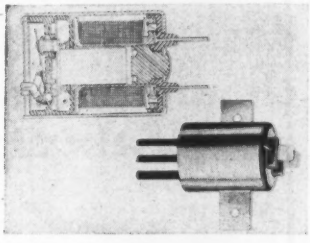
six and eight-pole motors have reduced "cogging" effect and provide more efficient low-speed operation on single and three-phase lines. External magnetic field is extremely low. **Howard Industries Inc.**, 1760 State St., Racine, Wis.

—Circle ITEM 487

Electromagnetic Switch

combines functions of relay and solenoid

Consisting of a totally enclosed switch and a soleniod-actuated



plunger, this new Reloid is applicable to washing machines, dryers, dish washers and other appliances and vending equipment. Metal case with molded bakelite end provides protection against moisture and dirt. Unit is available for voltages from 6 to 115 v, ac or dc, and contacts are rated at 8 amp, 115 v, noninductive. Standard contact arrangement is single pole, double throw. Dimensions are 2 11/32 x 1 7/32 x 1 7/32 in. **Guardian Electric Mfg. Co.**, 1621 W. Walnut St., Chicago 12, Ill.

—Circle ITEM 488

Lubrication System

provides central lubrication source

Lub-O-Jet is a positive, self-contained lubrication system that delivers oil under pressure to single or multiple bearing points. Pressure pump is built into a 4-oz shatterproof reservoir; oil supply is constantly visible. Six-outlet

All off-the-highway earth-moving equipment... dozers, scrapers, dump trucks... pose special hydraulics problems. The bulk, tonnage, and rugged service impose conditions that shoot an "ordinary" or "standard" formula full of holes. This is true of all heavy-duty equipment and especially so with long-stroke telescopic cylinders!

HYDRECO®

LONG-STROKE HYDRAULIC TELESCOPIC CYLINDERS

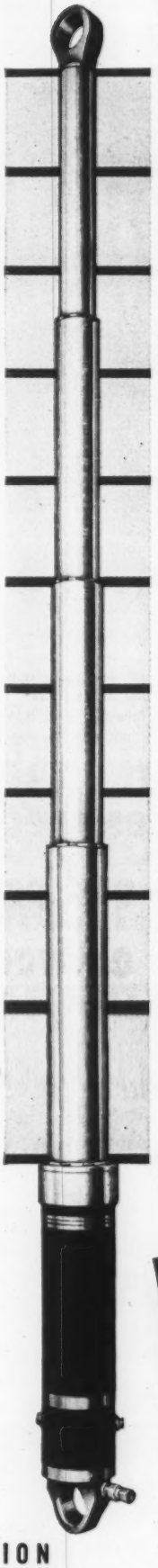
HYDRECO Cylinders are the result of many years of design and production experience. They're custom built for the service they face. They can be designed to meet your special requirements of space, mounting, function and load. You can have HYDRECO Cylinders with strokes to 20 feet or more and for loads requiring outer sleeves as large as 10 inches in diameter and system pressures to 1500 psi.

Telescopic cylinders are tough to build. No other cylinder calls for such close tolerances and perfect finish... no other type requires so much in design and production "know-how." Engineers who want "the bugs" out of their heavy-duty mobile equipment from the start specify HYDRECO!

Whether your problem involves 1 ton or 75 tons, the broad experience of HYDRECO engineers in finding the *right* answer can save you time, money and grief.

Write

—let HYDRECO engineers show you how you can improve your equipment with custom-built HYDRECO Telescopic Cylinders.



BIG DART EQUIPMENT SPEEDS CONSTRUCTION

OFF-THE-ROAD DUMP TRUCKS CARRY 75 YARDS PER LOAD

It's no problem at all to carry away, in a single load, half the dirt from an average home basement excavation. Modern off-the-highway dump trucks, hauling 75 tons or more of earth and over-burden, make short work of moving a hill or filling a valley.

Dumping these giant loads is done by means of big Telescopic Hydraulic Cylinders. Because truck bodies are so large, they require cylinders of unusually long stroke and capacity to raise them to full dumping position. During this operation it's an absolute "must" that all sleeves extend smoothly with no sticking or binding. Above all, safe operation is essential.

Downtime with this equipment costs big money. These giant trucks run day and night, rain or shine, on all sorts of jobs — so, cylinder maintenance must be negligible.

Many truck builders have made these big models practical and profitable with HYDRECO Fluid Power. Their experience has shown that HYDRECO Cylinders do the job and that they're safe, smooth operating and require a minimum of maintenance.

One of these builders is the Dart Truck Company, Kansas City, Mo., whose new 75-Ton capacity dump body is shown here. This model uses two 120-inch stroke HYDRECO Telescopic Cylinders. Fluid Power for the circuit is provided by two HYDRECO Pumps and control is by means of a HYDRECO Hollow-Plunger Valve.

ENGINEERS

Exceptional opportunities for men of imagination to express new ideas in the design and development of Fluid Power Components. Company expansion and progress promise rewarding futures for engineers who qualify. Write, giving experience and full details.

KALAMAZOO Division
The New York Air Brake Company
9006-4 E. Michigan, Kalamazoo, Mich.

Gentlemen: We'd like to discuss the subject of Telescopic Cylinders with one of your engineers. We understand there is no cost or obligation for this cooperation.

Name_____

Company_____

Address_____

City_____ Zone____ State_____

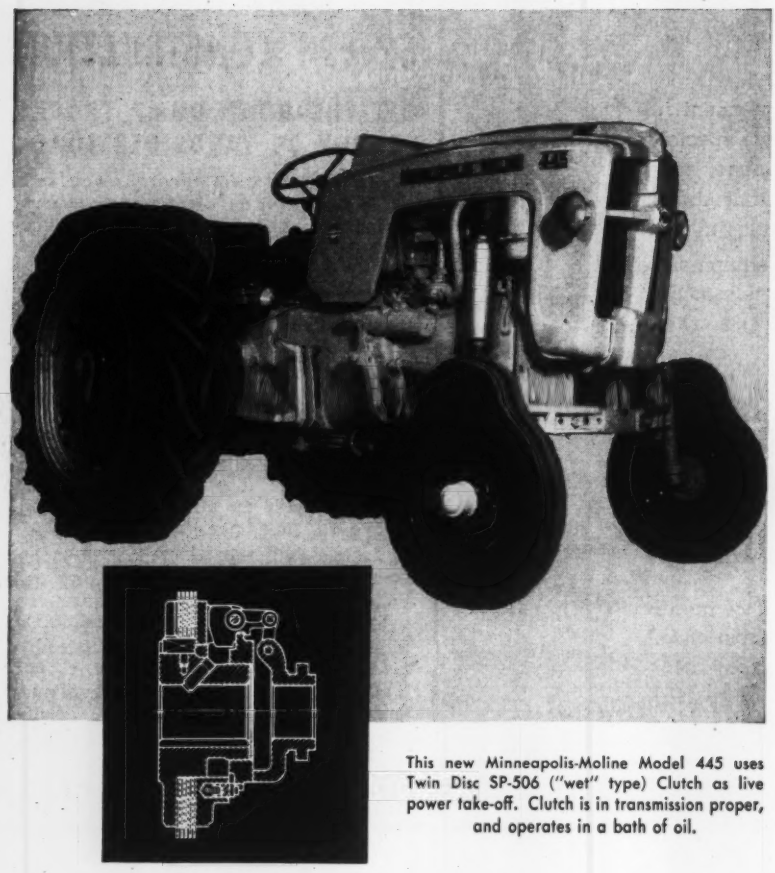
Member NFPA

KALAMAZOO DIVISION
THE NEW YORK AIR BRAKE COMPANY

9006 E. MICHIGAN • KALAMAZOO • MICH.

INTERNATIONAL SALES OFFICE, 90 WEST ST., NEW YORK 6, N. Y.

—ITEM 664—



This new Minneapolis-Moline Model 445 uses Twin Disc SP-506 ("wet" type) Clutch as live power take-off. Clutch is in transmission proper, and operates in a bath of oil.

Twin Disc provides specific answers to clutch and power take-off problems on tractors

For more than *30 years,* Twin Disc Engineers have worked closely with designers and manufacturers of farm machinery — to provide *specific answers* to their clutch and power take-off problems.

A typical example of this long, successful relationship is the *custom designed* SP-506 ("wet" type—multiple plate) Clutch used as a live power take-off on the new Minneapolis-Moline Model 445.

In addition to farm tractors, such as this, and the Oliver Super 55 — Twin Disc products appear in a number of diversified forms — from clutches in the newest Case Field Forage Harvester to torque converter components in the newest and largest crawler tractors, manufactured by Allis-Chalmers, Caterpillar and International Harvester.

Twin Disc is prepared to *custom design* clutches for *your specific needs* —using many standard components to create *minimum tooling charges* and *low unit prices.* If you have a clutch or power take-off problem, write or call Twin Disc Clutch Company, Racine, Wis.

TWIN DISC

CLUTCHES AND HYDRAULIC DRIVES

TWIN DISC

Friction Clutches and Fluid Drives

TWIN DISC CLUTCH COMPANY, Racine, Wisconsin • HYDRAULIC DIVISION, Rockford, Illinois

Branches or Sales Engineering Offices: Cleveland • Dallas • Detroit • Los Angeles • Newark • New Orleans • Tulsa

—ITEM 665—

For More Information Circle Item Number on Yellow Card—page 19

New Parts

distributor is connected to the reservoir assembly. Plastic ⅛-in. O.D. tubing, attached to the dis-

tributor outlets, delivers filtered oil to bearing points simultaneously when the pump is stroked. The unit is 5¼ in. high and weighs 9½ oz. **Trico Fuse Mfg. Co.,** 2948 N. Fifth St., Milwaukee 12, Wis.

—Circle ITEM 489

Plastic Laminate

resists temperatures to 400 F

Fluocarbon plastic laminate, consisting of a 10-12 mil continuous layer of Kel-F plastic on glass cloth, can be adhesive-bonded to contoured surfaces and has many lining and surfacing applications. Sheets can be cut with a knife and can be cold or hot formed to flat or curved surfaces. Characteristics of the laminate include resistance to temperatures up to 400 F, flexibility at low temperatures, resistance to chemicals, low permeability, high abrasion resistance and high tensile strength. Material is nontoxic and does not stick. It is available in 36 x 46-in. sheets from **Garlock Packing Co.,** Palmyra, N. Y. and **U. S. Gasket Co.,** 602 N. Tenth St., Camden, N. J.

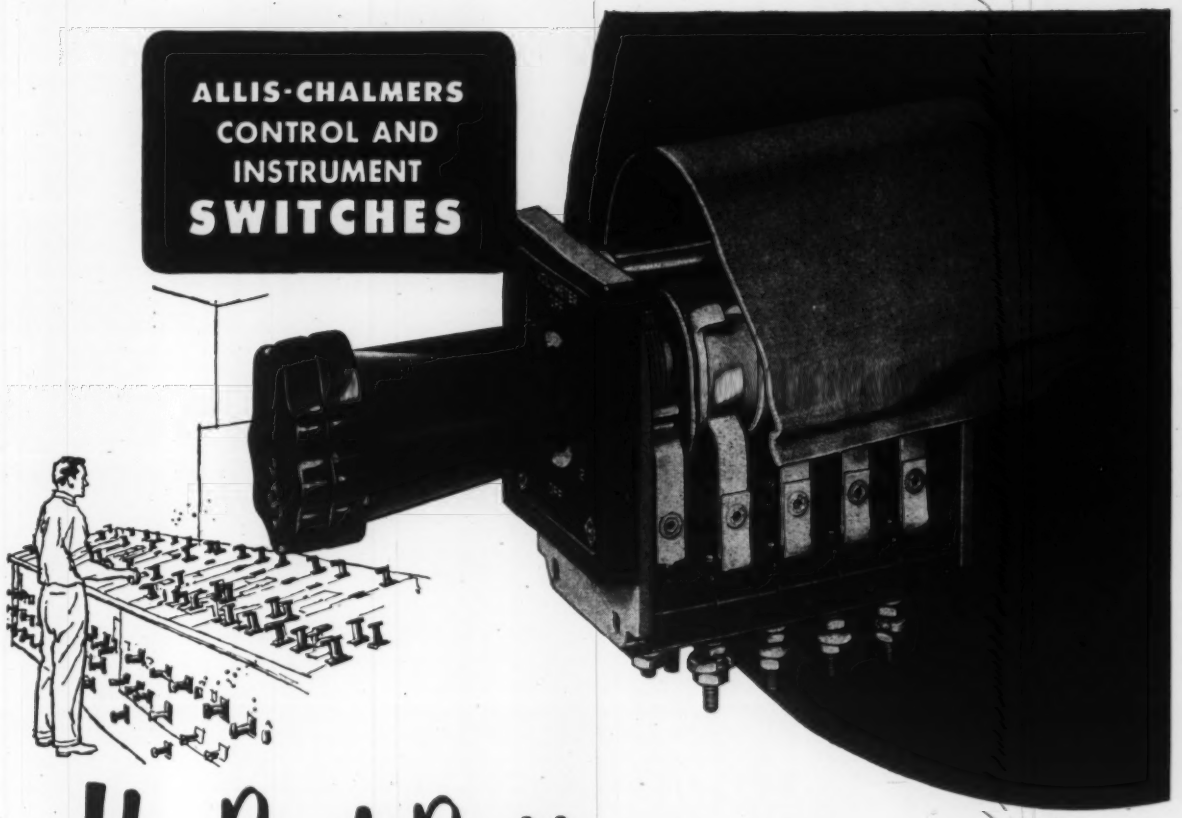
—Circle ITEM 490

Relays

available in variety of coil and contact styles

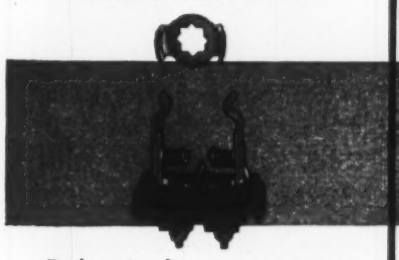
Representative of new line of relays are (1) Single-coil type A with double-stacked spring combinations, suitable for switching loads to 10 amps, 115 v ac; fast-

ALLIS-CHALMERS
CONTROL AND
INSTRUMENT
SWITCHES



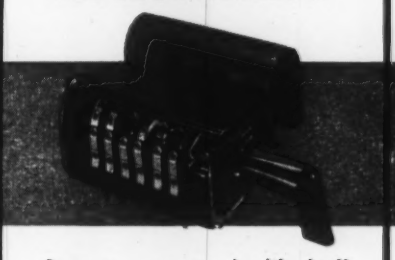
Mr. Panel Builder... here's what you should look for in control and instrument switches

FLEXIBILITY



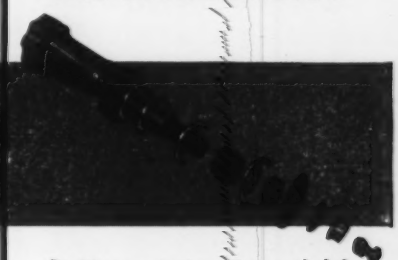
Each pair of stationary contact fingers is mounted individually. Unit construction facilitates adding stages and makes contact replacement easy.

ACCESSIBILITY



Snap-on cover can be lifted off —requires only a minimum space for removal. Arrangement of terminals permits wiring without removing switch cover.

DEPENDABILITY



Positive contact motion and definite contact position are made possible through the use of square shaft and star-holed contact segments.

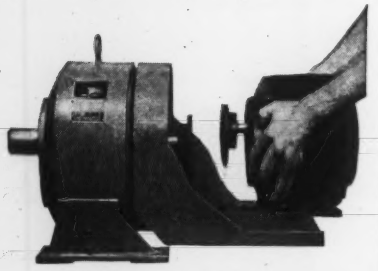
Allis-Chalmers manufactures switches in a wide variety of types and contact arrangements to meet your specific requirements — with standard models available from stock. Write Allis-Chalmers, General Products Division, Milwaukee 1, Wisconsin. Ask for Bulletin 14B8112.

A-4952

A-C ALLIS-CHALMERS

ALLIS-CHALMERS

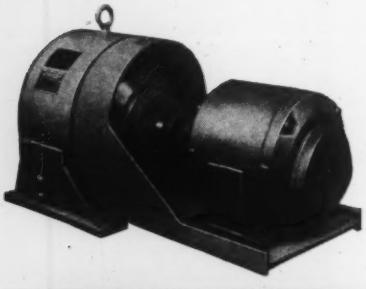
Change MOTORS ...in Minutes



...with the Phillie Gear UTILITY GEARMOTOR

Motors can be interchanged or replaced in a matter of minutes, merely by unbolting the old motor, separating the coupling halves, and bolting-on the new motor. No long and costly "down-time". Replacement of standard foot mounted motors is not limited to the original make of motor.

The Philadelphia "Utility" Gearmotor is of heavy, non-corrosive cast iron construction. The rugged design of the motor support eliminates alignment and vibration problems between reducer and motor. These Units are available with motors up to 60 h.p., in full range of AGMA output speeds—they can be furnished from stock for prompt delivery, either with or without motors. The "Utility" Gearmotor is equipped with the patented and widely used Philadelphia "Sphereflex" Flexible Coupling, which provides additional versatility of mounting. Send for complete Gearmotor Catalog, and be convinced.



PHILADELPHIA GEAR WORKS INCORPORATED

ERIE AVE. AND G ST., PHILADELPHIA 34, PA.

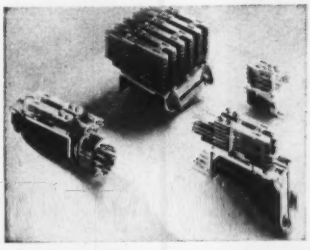
NEW YORK • PITTSBURGH • CHICAGO • HOUSTON • LYNCHBURG, VA

BALTIMORE • CLEVELAND

Industrial Gears & Speed Reducers • LimiTorque Valve Controls

—ITEM 667—

New Parts



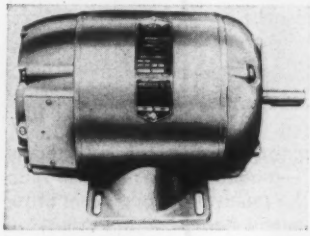
acting and slow-acting versions are available, (2) Type-B gang relays with up to 60 Form-A contacts, supplied with one or two coils, (3) Type C, consisting of two relays on a common frame, (4) Type-D lightweight, shock-resistant relay, withstands shocks to 50 *g* and remains operated under shocks to 20 *g*, (5) Vibrating-reed model for providing alternating current from a direct-current source. This style (3A or 3B) can be used in conjunction with slow release relays to produce extended relay release, or wired in self-interrupting circuits to produce time pulses. **Stromberg-Carlson Co.**, Rochester 3, N. Y.

—Circle ITEM 491

Slip-Ring Motors

have small frame sizes and fractional hp ratings

Designed for use on conveyors, hoists, cranes and other machines requiring operator-regulated running speeds, these motors are available in No. 66 frame size



with ratings from ¼ to 1½ hp. Motors have speed selections from 50 to 100 per cent of full-load speeds, which are either 1200 or 1800 rpm, depending on power rating. High starting torque is provided by starting in a slow-speed position, full speed being attained through a series of steps. **Reuland Electric Co.**, 3001 W. Mission Road, Alhambra, Calif.

—Circle ITEM 492

TRADE MARK TO HALLMARK

Through the years, our trade mark has become a mark of quality that stands for the simplicity, efficiency and dependability of Curtis Universal Joints . . . the Hallmark of the industry.

In a wide range of applications, Curtis Joints offer the designer assurance of long life and trouble-free performance — because they are quality-controlled at each step of manufacture.

CURTIS UNIVERSAL JOINTS

- 14 sizes always in stock ⅜" to 4" O.D.
- Fewer parts, simpler construction
- Complete equipment for government tests

Our catalog torque and load ratings are substantiated by constant tests. You can depend on them.

Not sold through distributors. Write direct for free engineering data and price list.

TRADE MARK CURTIS

UNIVERSAL JOINT CO., INC.

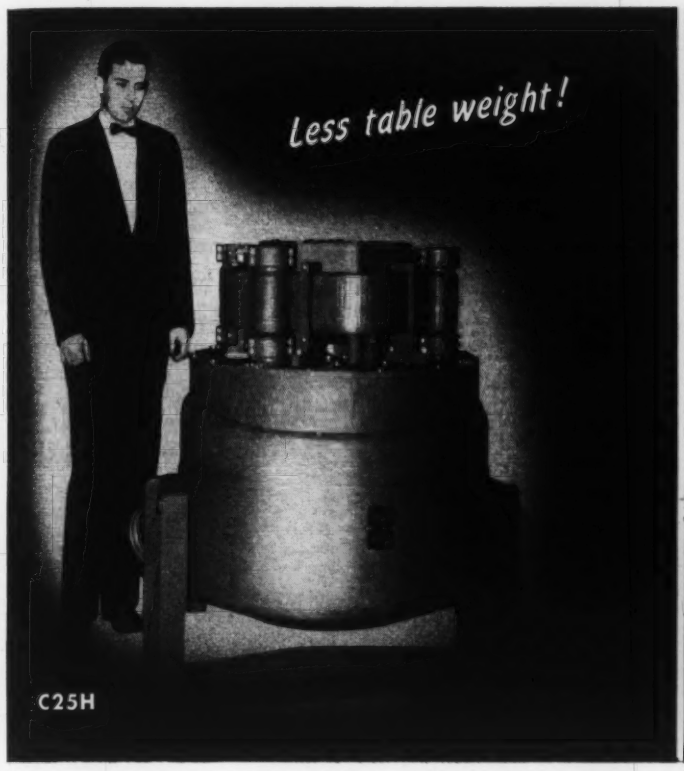
5 BIRNIE AVENUE, SPRINGFIELD, MASS.

As near to you as your telephone

A MANUFACTURER OF UNIVERSAL JOINTS SINCE 1919

—ITEM 668—

Now... shakers for random motion vibration testing



Three new high performers which are particularly adapted to random motion vibration testing join the unique line of MB Vibration Exciters. With them, virtually every modern test requirement for sinusoidal or random motion can be met with increased data-reliability.

Model C6 extends testing range to 5000 cps without axial resonance . . . has a moving element weighing only 3½ pounds . . . delivers 200 pounds of force.

Model C10 develops 1200 pounds force . . . and up to 67.5 "g". Usable to 3000 cps, it has a suspension system that assures true rectilinear motion, with first resonance of unloaded 17½-pound moving element over 3000 cps.

Model C25H rated at 3500 pounds force, now has a newly designed moving table assembly weighing only 75 pounds . . . yet the axial resonance remains well above operating limit of 2000 cps.

These shakers put into practice the advanced vibration engineering for which MB's specialists are known, and which is always ready to assist you.

GOOD VIBRATION EXCITER INSURANCE

Remember, MB maintains a service department second to none in *scope* of service and size. It does installation checkouts, instructs operating personnel, and "trouble-shoots". Such service assures that you'll get the most from your equipment.

Ask for recommendations on your specific needs, or look over the MB line by sending for Bulletin 420-B-3

MB manufacturing company
A division of Textron American, Inc.
1060 State Street
New Haven 11, Conn.

HEADQUARTERS FOR PRODUCTS TO CONTROL VIBRATION . . . TO EXCITE IT . . . TO MEASURE IT.

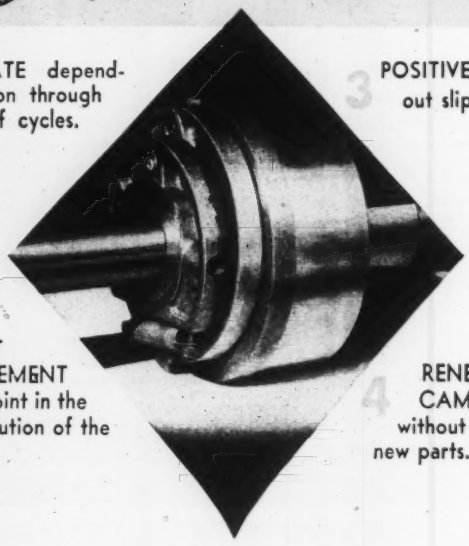
—ITEM 669—
For More Information Circle Item Number on Yellow Card—page 19

HILLIARD CLUTCHES FOR POWER CONTROL DESIGNS

HILLIARD
Single Revolution CLUTCH

1 ACCURATE dependable action through millions of cycles.

3 POSITIVE motion without slip or lag.



2 INSTANT ENGAGEMENT at any point in the the revolution of the driver.

4 RENEWABLE CAM SURFACES without machining or new parts.

The Hilliard Single Revolution Clutch *is automation* because it provides precise accurate intermittent motion automatically. Control can be electrical or mechanical.

The use of Hilliard Single Revolution Clutches has improved the operation of tube straightening and cut-off machines—shears—conveyors—riveting and fastening units—case loaders—bottle unscramblers—weighing and packaging—indexing and feeding—marking—punching—textile and business machines—radar apparatus—proportionate pumps—and many other types of mechanisms.

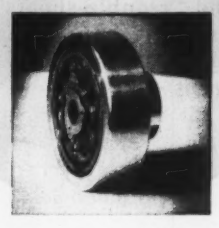
WRITE TODAY FOR BULLETIN 239 WITH COMPLETE INFORMATION.

• OTHER HILLIARD CLUTCHES •

CONSIDER AUTOMATION - INVESTIGATE THESE PRODUCTS

OVER-RUNNING CLUTCHES for automatic instantaneous engagement and release on two speed drives, dual drives and ratchet or backstop action. Ask for Bulletin 231.

HILLIARD - TWIFLEX CENTRIFUGAL COUPLING for smooth, easy starting of any load automatically with overload protection and ability to accommodate shaft misalignment. Ask for Bulletin CE-3.



SLIP CLUTCHES for overload protection, or constant torque and to provide constant tension and permit speed variation on rewind stands. Ask for Bulletin 300.

THE HILLIARD CORPORATION
MANUFACTURING CLUTCHES FOR OVER 50 YEARS
103 W. FOURTH ST. ELMIRA, NEW YORK

IN CANADA: UPTON • BRADEEN • JAMES, LTD.

—ITEM 670—
For More Information Circle Item Number on Yellow Card—page 19

ENGINEERING DEPARTMENT

EQUIPMENT

Folding Drawing Board

mounts in center desk drawer

Designed for personnel whose duties require occasional drafting, this Foldaway drawing unit consists of a drawer, drawing board and parallel rule. The assembly

can be attached to any conventional desk or table top. When folded away, the board is completely out of sight, leaving the desk top completely clear. Self-contained suspension fixtures equipped with nylon tracks permit the drawer to slide smoothly. The board itself, attached to the drawer with hinges, moves into position on the desk top at a comfortable working slope. Two sizes are available: a small model with a 24 x 24 in. drawer and a 20 x 15 in. board; a large model has a 30 x 30 in. drawer and a 26 x 21 in. board. **Aetna Steel Products Corp.**, Arnot-Jamestown Div., 922 Park Ave., Baltimore, Md.

—Circle ITEM 493

Force Indicators

with capacities from 50 to 200 lb

Series D precision force indicators are available with capacities from 50 through 200 lb. Accuracy varies

In The Continental *Mark II . . .*

PARKER Die Castings, of Course

PARKER
SALES ENGINEERS

CHICAGO 49, Ill.
Ollie J. Berger Company • 2059 East 72 Street

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To match the skilled craftsmanship exemplified in the CONTINENTAL Mark II, these Parker Die Castings were chosen as components for this fine motor car.

Here is convincing proof of Parker's skill and craftsmanship in the die casting of zinc and aluminum to exacting specifications.

For your die casting requirements, take advantage of Parker's 50 years' experience. Just call the nearest Parker sales engineer or write the factory direct.

Parker White Metal Company • 2153 McKinley Ave., Erie, Pennsylvania

PARKER

high pressure
ALUMINUM and ZINC
die castings
POWDERED METAL PARTS

—ITEM 671—
For More Information Circle Item Number on Yellow Card—page 19

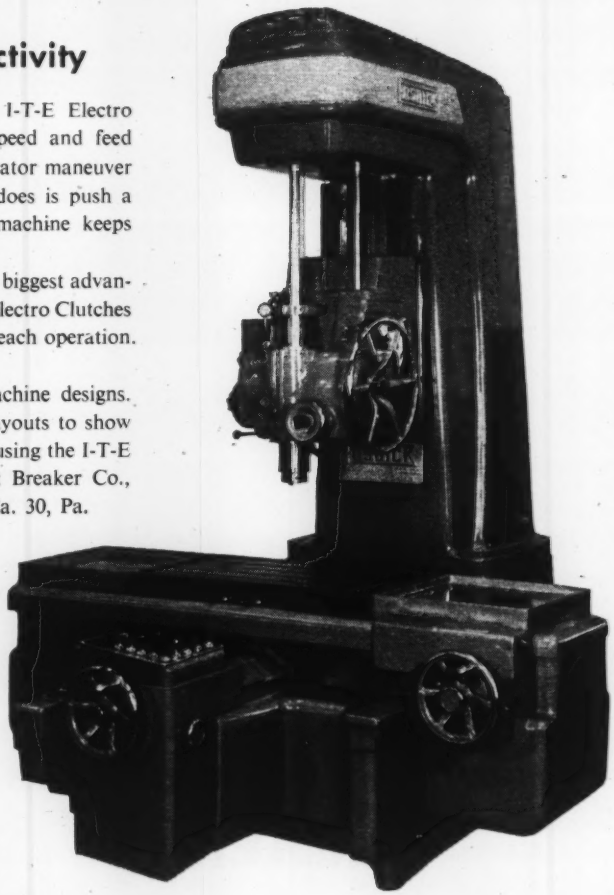
I-T-E ELECTRO CLUTCHES MAKE POSSIBLE SPEED AND FEED CHANGES IN 1/2 SECOND

Easier operation boosts productivity

The Fosdick Machine Tool Co. has now incorporated I-T-E Electro Clutches into its precision jig borers. Formerly every speed and feed change meant the machine had to be stopped and the operator maneuver a mechanical slide-gear shifting mechanism. Now all he does is push a button on the conveniently located control panel. The machine keeps running; keeps producing.

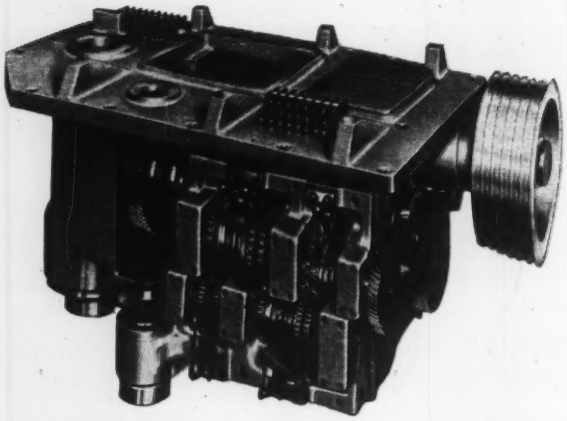
Easier operation and increased production—these are the biggest advantages that I-T-E Electro Clutches can add to machine tools. Electro Clutches make it easier to operate machines at their best speeds for each operation. In addition, they have transmission gear space.

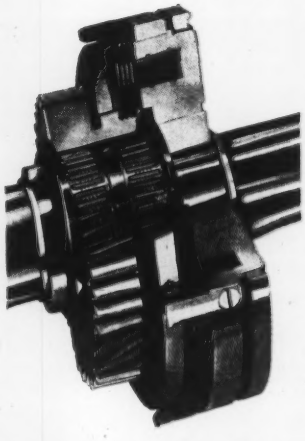
I-T-E Electro Clutches are available to fit existing machine designs. I-T-E application engineers will be glad to help prepare layouts to show you the space-saving possibilities and ease of control when using the I-T-E Electro Clutches. Write for Bulletin #5306. I-T-E Circuit Breaker Co., Transformer-Rectifier Division, 19th & Hamilton Sts., Phila. 30, Pa.



FOSDICK PRECISION JIG BORER
MODEL H-1015

SPACE SAVER. Complete transmission for the Fosdick machine. Notice compactness and simplicity for mounting I-T-E Electro Clutches on same shafts with gears. Clutches operate right in housing with oil lubricant.





NO ADJUSTMENTS. The I-T-E Electro Clutch is simple, compact, requires no adjustments for wear. Available in torque ratings from 3.2 ft. lb. to 45,000 ft. lb.

I-T-E CIRCUIT BREAKER COMPANY • Transformer-Rectifier Division

—ITEM 672—

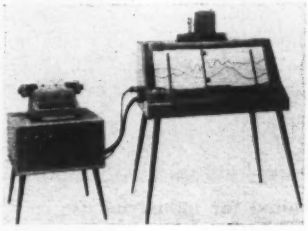
from ¼-lb in the low-range indicator to 1 lb in the high-range unit. Designed for hand operation or for use in permanent test set-ups, the indicators have detachable, heavy-gage handles which latch into position; threaded mounting holes are also provided in the back of the instrument case. Dial indicators are jeweled and the compensated spring mechanism has a gradient as low as 0.10 per cent. **Hunter Spring Co.**, Lansdale, Pa.

—Circle ITEM 494

Data Reduction System

reads out automatically to typewriters or punch machines

Designed to function as a complete data reduction system, this new



oscillograph trace reader handles either film or opaque records. Width of record can vary from 16-mm film to 12-in. paper. Designated OSCAR Model J, the low-cost unit has a reading head which will accept linear or nonlinear calibrations. Accuracy is ±1 per cent, and readout is initiated less than 0.15 sec after depression of readout switch. Containing no vacuum tubes, transistors or diodes, the unit can operate an electric typewriter, tape or card-punch machines. **Benson-Lehner Corp.**, 11930 Olympic Blvd., Los Angeles 64, Calif.

—Circle ITEM 495

Impact Noise Analyzer

measures instantaneous levels and time durations

Impact noises, such as those produced by business machines, punch presses and other mechanisms, are evaluated by this Type 1556-A Impact-Noise Analyzer. The instrument measures both maximum in-

by Design

BIJUR

AUTOMATICALLY ASSURES CUSTOMER SATISFACTION

the user of your machines

- Increases Productive Capacity
- Saves on Repair Bills
- Eliminates Costly Hand Oiling
- Reduces Downtime
- Lengthens Machine Life

WITH Bijur Automatic Lubrication as an integral part of your equipment, your customers benefit from continuous peak production. Plant after plant reports increased out-put and greatly reduced maintenance costs with Bijur-equipped machines. Costly downtime for lubricating by hand is eliminated. Every bearing is metered the proper quantity of oil at predetermined intervals. Work spoilage and bearing troubles caused by over-lubrication are avoided. Fire hazards are reduced. Personnel accidents are prevented.

Bijur gives you the opportunity to add customer satisfaction through improved machine performance.

More than a million Bijur-protected machines are in use. Hundreds of leading manufacturers standardize on Bijur as "built-in" components of their machines. Bijur emphasizes custom-engineering, and we will gladly co-operate in designing a system to meet the specific requirements of your machine.

Design Bijur into your machines now in production or in the planning stage. Write for literature and engineering information.

0-3

2389

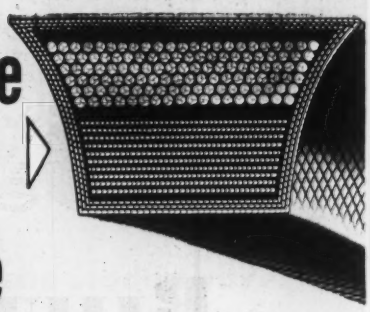
BIJUR LUBRICATING CORPORATION

Rochelle Park, New Jersey

Pioneers in Automatic Lubrication

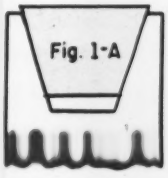
—ITEM 673—

Why this curve lengthens V-belt life



THE CONCAVE SIDES (U.S. Patent 1813698) of every Gates V-Belt are a precisely engineered curve. This curve greatly lengthens V-belt life for this interesting reason:

When you bend a Gates V-Belt, just as it is bent around a sheave, the concave sides (Fig. 1) become straight. Therefore, the belt makes full contact with the sheave, gripping the sides evenly (Fig. 1-A) and wear is distributed uniformly across the sidewalls of the belt. Naturally, uniform wear lengthens belt life; saves on replacement costs and cuts down-time.

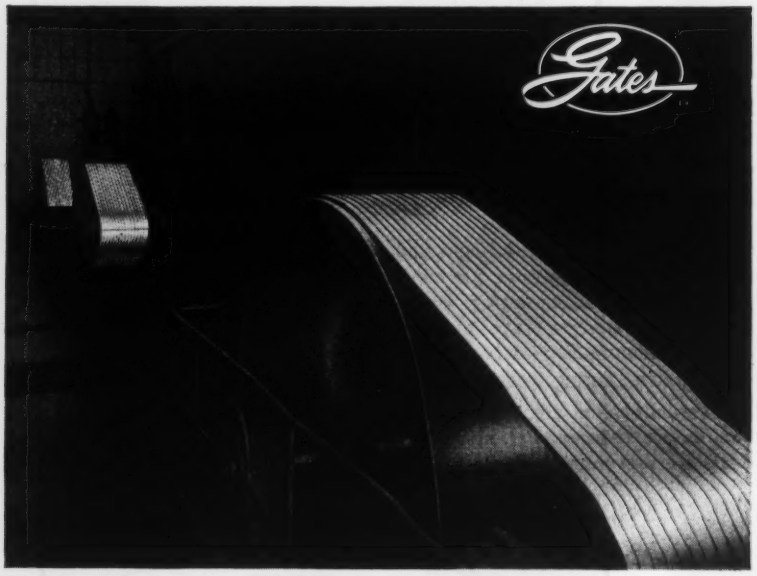


Now see what happens when you bend a straight-sided belt. (Fig. 2) Just feel the sidewalls *bulge out* at the bend. The bulge causes *uneven* contact with the pulley, as in Fig. 2-A. And uneven contact causes excessive wear at points shown by arrows; belt life is shortened.

Cut costs by getting longer wear from your V-belt drives. Specify Gates Vulco Rope—the V-belt with concave sides. Your nearby Gates distributor will supply your needs promptly. The Gates Rubber Co.—*World's Largest Maker of V-belts.*

There are Gates Engineering Offices and Distributor Stocks in all industrial centers of the United States and Canada, and in 70 other countries throughout the world.

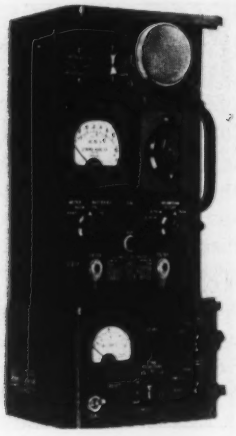
TPA-74



Gates Vulco Rope Drives

—ITEM 674—

Engineering Equipment



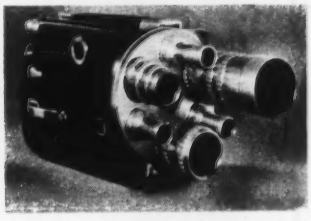
stantaneous sound level and the time duration of the sound wave. It is operated from the outputs of conventional sound-level meters or spectrum analyzers. Additional uses include the measurement of reverberation time and the damping effect of sprayed coatings. **General Radio Co.**, 275 Massachusetts Ave., Cambridge 39, Mass.

—Circle ITEM 496

Movie Camera

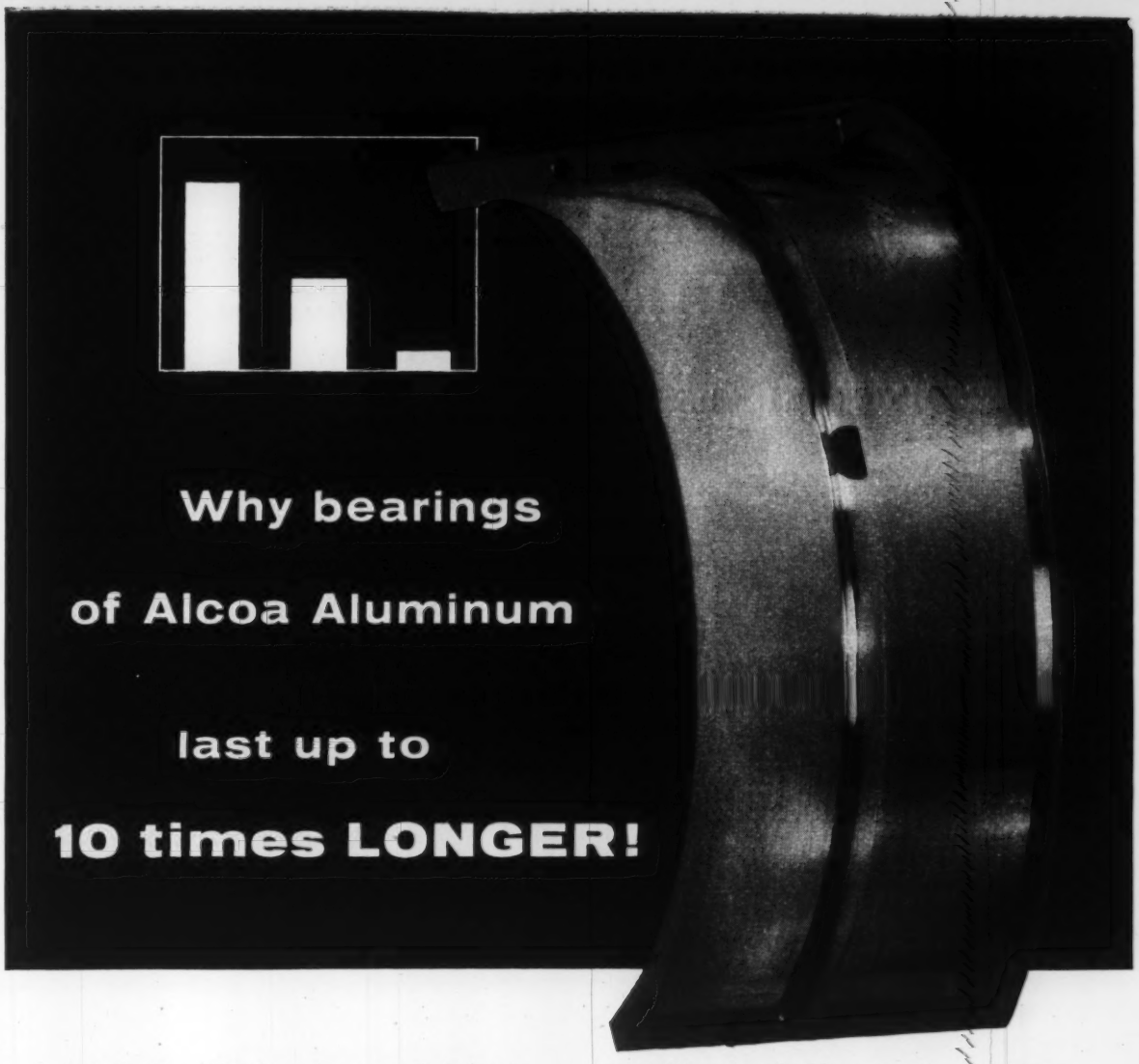
suited for industrial use

Cine-Kodak K-100 movie camera mounts three lenses together with matching viewfinders. Lenses are available in the 15 to 150 mm focal-length range. Power spring motor,



which is pre-stressed, exposes 40 ft of film at a single winding and is accurately speed governed. Speed range is 16 to 64 frames per second, plus single-frame exposure. Either single-perforated film for sound recording or standard double-perforated film is accommodated in 50 and 100-ft rolls. Special effects, such as fades, dissolves and multiple exposures can be obtained for increased versatility in photographing industrial equipment and installations. **Eastman Kodak Co.**, Rochester 4, N. Y.

—Circle ITEM 497



A leading diesel engine manufacturer increased the life of their crankshaft bearings *at least 10 times* by switching from babbitt to solid bearings of Alcoa® Aluminum. Bearings of Alcoa Aluminum are outperforming babbitt and bronze in hundreds of other applications—because aluminum has an *unmatched combination of advantages.*

Highest load capacity—Solid aluminum bearings withstand the highest loads—up to 10,000 psi on projected area in certain applications. Aluminum bearings are the only solid bearings suitable for heavy-duty service.

20° cooler running—Aluminum is the best heat conductor of *all* bearing metals. Result: aluminum bearings run up to 20° cooler than other bearings. Where hot spots are likely, there's far less danger of seizure.

Excellent conformability—Aluminum has good ductility, conforms readily to misalignment of shafts or nonparallelism of pins. This reduces unit loading, makes bearings last longer.

Handles dirt well—Dirt in the oil? Aluminum embeds particles far better than bronze, but not as deeply as babbitt. Dirt particles roll out of aluminum more easily and are trapped by the filter.

No corrosion problem—With its excellent corrosion resistance, aluminum is unaffected by additives in oils. No protective coatings are needed.

No failure damage—With solid aluminum bearings, there's no chance of journal damage in event of bearing failure.

Great design flexibility—The *structural* properties of Alcoa bearing alloys give you interesting design opportunities. For example, solid aluminum connecting rods which eliminate the need for insert bushings. Full-floating bearings. Water-cooled bearings with integral cooling passages.

Carefully investigate cast bearings of solid Alcoa Aluminum. Check your bearing manufacturer or write: Aluminum Company of America, 1986-D Alcoa Building, Pittsburgh 19, Pennsylvania.

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TELEVISION'S FINEST LIVE DRAMA
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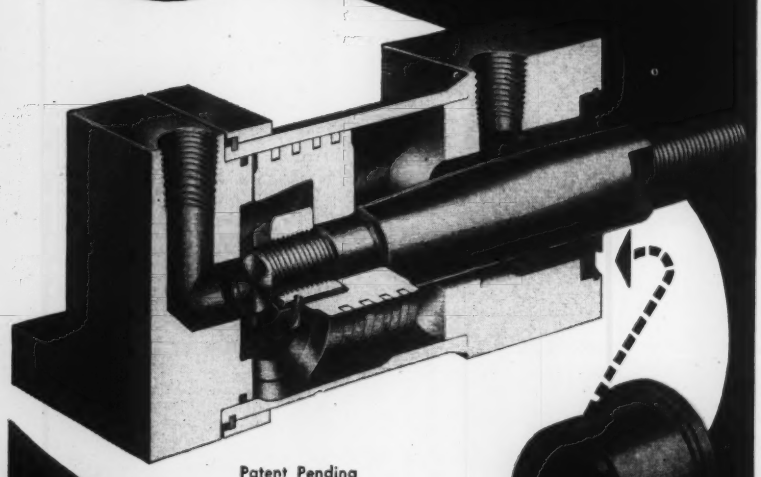
Your Guide to the Best in Aluminum Value

—ITEM 675—

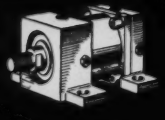
High Pressure HYDRAULIC CYLINDERS



Patent Pending

Cut downtime with "quick-change" rod packing cartridge

- 2,000 P.S.I.
- I. I. C. STANDARDS
- COMPACT DESIGN
- OPTIONAL ROD SIZES
- ALL-STEEL CONSTRUCTION
- 11 TYPES OF MOUNTINGS
- 11 BORE SIZES—1½" TO 8"
- UP-TO-DATE ENGINEERING



The S-P "quick-change" packing cartridge is easily removed for servicing seal or wiper. ***Cuts downtime . . . speeds production.*** S-P Hydraulic Cylinders have ***every*** modern design feature. Representatives in principal cities. Prompt deliveries. Send for Catalog 104. The S P Manufacturing Corp., 12415 Euclid Ave., Cleveland 6, Ohio.

THE S-P MFG. CORP. — Cleveland
A Bassett Company
PRECISION PRODUCTS SINCE 1916
AIR AND HYDRAULIC CYLINDERS • POWER CHUCKS • ROTATING AIR CYLINDERS
COLLET AND DRILL PRESS CHUCKS • AIR PISTONS VALVES AND ACCESSORIES

THE ENGINEER'S Library

Recent Books

Electronic Transformers and Circuits, 2nd Edition. *By Reuben Lee; 360 pages, 5¾ by 9 inches, clothbound; published by John Wiley & Sons Inc., 440 Fourth Ave., New York 16, N. Y.; available from* MACHINE DESIGN, *$7.50 postpaid.*

Directed to electronic equipment engineers, this reference book concerns the design of transformers for electronic apparatus and the effects of transformer characteristics on electronic circuits. The second edition has new chapters concerning magnetic amplifiers and pulse circuits. Other sections have been brought up to date. Sections on electronic amplifiers and wave filters have been deleted.

•

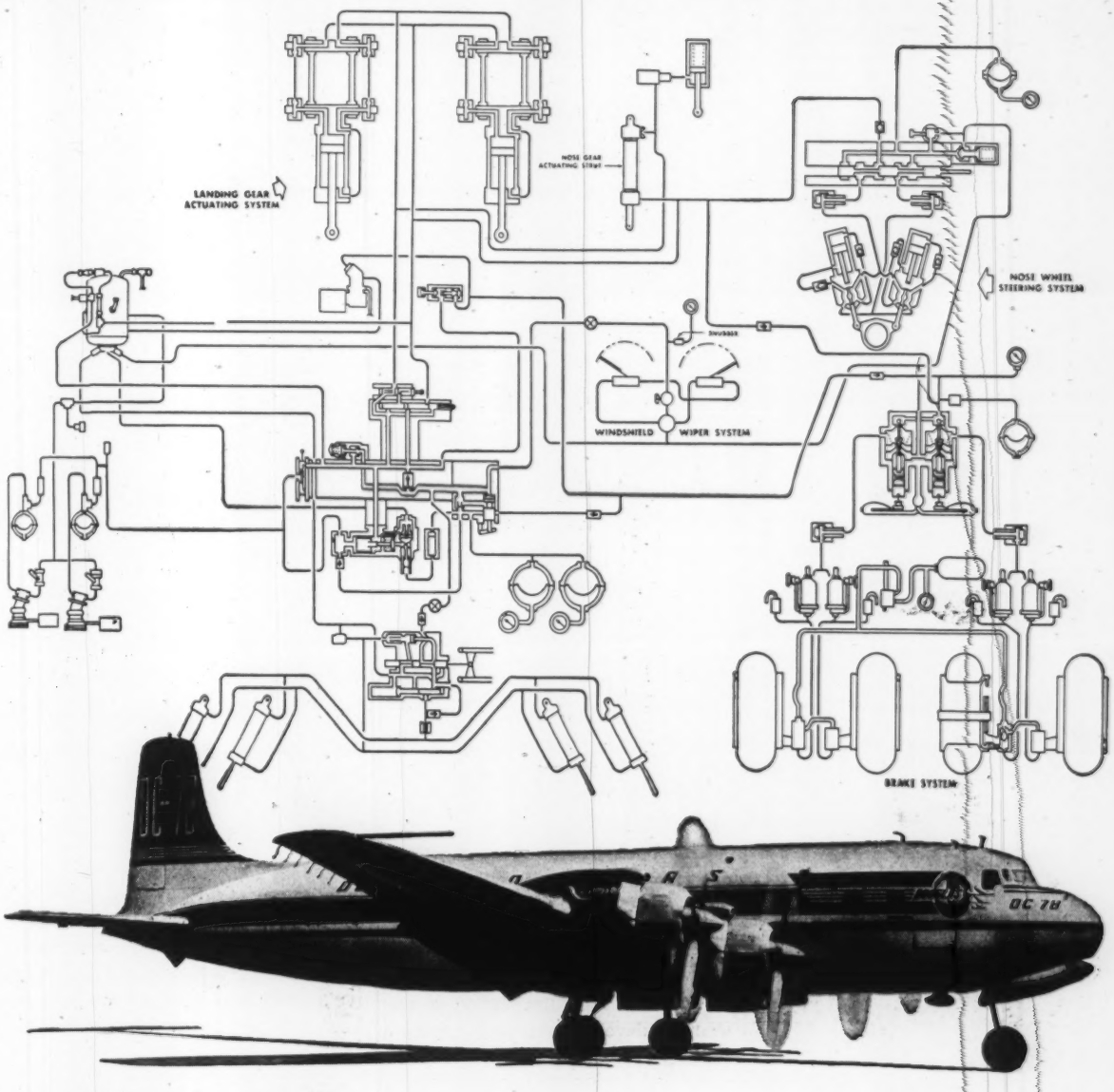
Technical Publications. *By C. Baker; 302 pages, 5¼ by 8½ inches, clothbound; published by John Wiley & Sons Inc., 440 Fourth Ave., New York 16, N. Y.; available from* MACHINE DESIGN, *$6.00 postpaid.*

This book is a guide to technical writing in industry. It outlines the needs of the user of technical publications and presents techniques for gathering information, writing text, preparing hand-drawn and photographic illustrations, and reproducing material by various duplicating and printing processes. A separate chapter concerns legal documents.

•

High Vacuum Technique, Third Edition. *By J. Yarwood; 208 pages, 5½ by 8½ in., clothbound; published by John Wiley & Sons Inc., 440 Fourth Avenue, New York 16, N. Y.; available from* MACHINE DESIGN, *$5.50 postpaid.*

As its subtitle indicates, this book concerns the theory, practice, and industrial applications of high-



Enjay Butyl rubber— vital artery in newest airliners

Douglas chooses Enjay Butyl for rubber components of the hydraulic systems in many of its famous DC-7 airliners. These components, which help assure the dependable operation of everything from wing flaps to landing gear, are proving over millions of air miles their durability and resistance to wear.

Versatile Enjay Butyl rubber may well have a place in *your* operation. It will pay you to investigate the many technical advantages it has over other types of rubber. Its price and ready availability are advantages, too. For full information, and for technical assistance in the uses of Enjay Butyl, contact the Enjay Company today.

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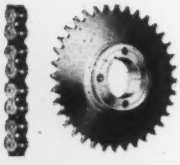
Enjay Butyl is the super-durable rubber with *outstanding* resistance to aging • abrasion • tear • chipping • cracking • ozone and corona • chemicals • gases • heat • cold • sunlight • moisture.

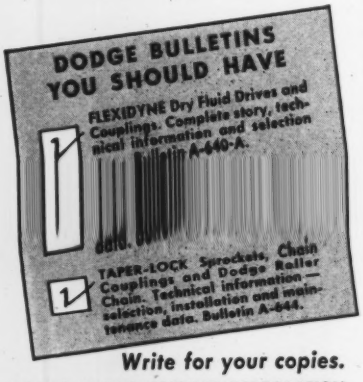
DODGE PRODUCTS you should know

FLEXIDYNE
THE DRY FLUID DRIVE

TAPER-LOCK
SHEAVES



TAPER-LOCK
SPROCKETS AND
DODGE ROLLER CHAIN


DODGE BULLETINS
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FLEXIDYNE Dry Fluid Drives and Couplings. Complete story, technical information and selection
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—ITEM 678—

The Engineer's Library

vacuum technique. A major section also covers the properties of materials important in high-vacuum operations. New and expanded material in this edition includes an analysis of commercial vacuum pumps, the gas ballast pump, large diffusion pumps and systems, new pump fluids, gaskets, valves, and methods of measuring vacuums both low and high.

•

Instrument Engineering—Vol. III, Applications of the Instrument Engineering Method, Part 1, Measurement Systems. *By Charles Stark Draper, head of the Department of Aeronautical Engineering; Walter McKay, associate professor of Aeronautical Engineering; and Sidney Lees, assistant professor of Aeronautical Engineering, all of the Massachusetts Institute of Technology; 879 pages, 8½ by 11 inches, clothbound; published by McGraw-Hill Book Co., Inc., 330 West 42nd St., New York 36, N. Y.; available from* MACHINE DESIGN, *$17.50 postpaid.*

This book is one of a set which describe and illustrate methods for finding solutions to measurement and control problems. The material is directed to engineers concerned with instrumentation in research, development and production. The content of Volume III is classified under the general headings (1) concepts, definitions, diagrams and notation for describing operating components and systems, (2) indication and measurement, (3) elements and components associated with instrument systems, (4) temperature measuring instruments, (5) electromechanical measuring instruments, (6) pressure measuring systems, (7) integrators and differentiators, and (8) vibration measurment and vibration isolation.

•

Handbook of Barrel Finishing. *By Ralph Enyedy; 255 pages, 7 by 10 inches clothbound; published by Reinhold Publishing Corp., 430 Park Ave., New York 22, N. Y.; available from* MACHINE DESIGN, *$7.50 postpaid.*

This book is directed to production and engineering personnel con-

COOPER ALLOY

CORPORATION BRIEFS

• Edited by GEORGE BLACK

VALVE CLINICS

In spite of our belief that the Cooper Alloy stainless steel valve offers the best in design and operating features, we take it to school regularly. This "school" consists of continual study by field engineers, design engineers and by industry itself subjecting it to intensive examination and reporting their findings at organized Valve Clinics.

Cooper Alloy Valve Clinics have been held in dozens of leading plants, including Dow, DuPont, Mathieson, Celanese, Pfizer and many others. Arrangements for such a clinic in your own plant may be made through our Public Relations Division.

"FLEX-ALLOY" STAINLESS PUMP

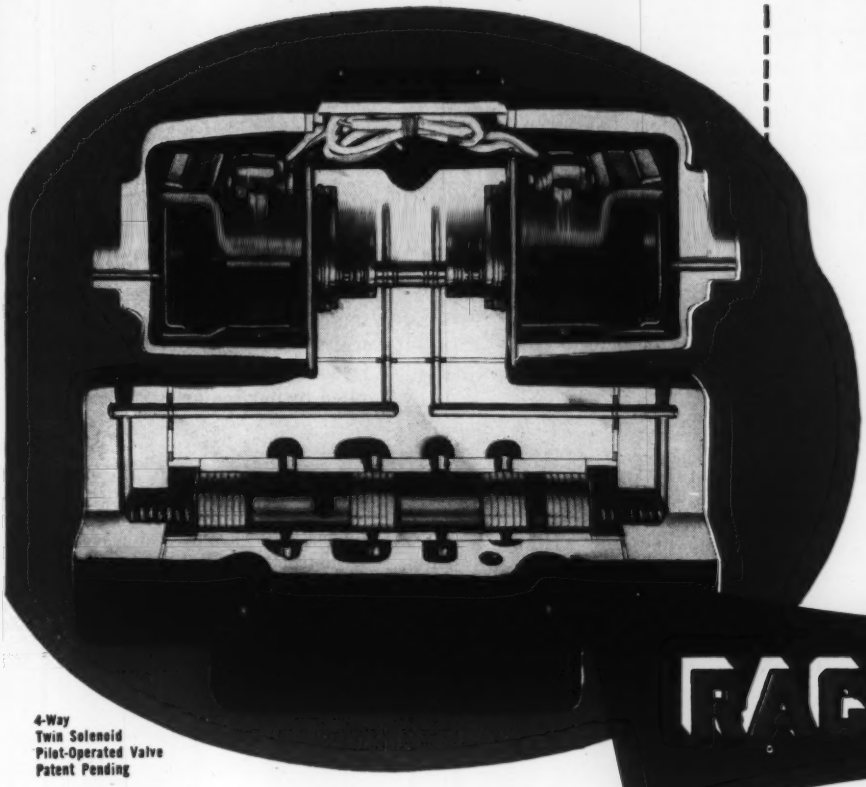
A new line of stainless steel rotory pumps for corrosive solutions, abrasive slurries and fluids which must be kept free from contamination has just been announced by our Vanton Pump & Equipment Division. Called "Flex-Alloy" these new pumps in type 304 or 316 stainless (other alloys on request) incorporate the same no-stuffing box, no-shaft seals, no-gasket features of the popular "flex-i-liner" plastic pump series. Full details are given in Bulletin VP561.

FAST AND COLD

On October 14, 1947, the Bell X-1 made history by flashing through the skies faster than sound. Cooper Alloy is proud to have been teamed with the Glasby Company in helping Bell Aircraft carve its notch in history by furnishing the 30" diameter, 3" wall stainless steel sphere required for handling the liquid nitrogen.

COOPER ALLOY
CORPORATION • HILLSIDE, N.J.

—ITEM 679—



4-Way
Twin Solenoid
Pilot-Operated Valve
Patent Pending

RACINE®

SLEEVE TYPE VALVES GIVE BETTER CONTROL

Proper control of oil flow improves the operation of your machines.

RACINE Sleeve Type Valves are designed with round drilled parts that assure smooth, control of oil to cylinders and fluid motors.

These RACINE Valves are provided with dust-proof solenoid covers — a pending patent includes a RACINE feature that prevents solenoid operation and injury to operator when covers are removed or loose.

Built to J.I.C. specifications RACINE Valves are approved for use in all critical applications. They are precision-built, compact, and rugged in design. Operating pressures to 2000 psi with full back pressure on exhaust port.

Your machine will operate better, with less maintenance because of longer life of RACINE Sleeve construction. Write today for complete catalog showing why "Sleeve Type Valves give Better Control."

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Variable Volume
Vane Type
Hydraulic Pump

PRESSURE BOOSTER
Up to 5000 psi
Up to 7:1 pressure ratio

FLUID MOTOR
Vane Type
50 to 3500 rpm
Pressures to 1500 psi

RESERVOIR
With Control Panel
Designed to your space
and circuit requirements

NFPA NATIONAL FLUID POWER ASSOCIATION

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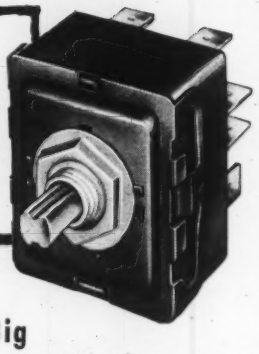
2073 Albert Street
RACINE, WISCONSIN, U.S.A.

This Little Switch Goes to Market

. . . in air conditioners, fans, unit heaters, appliances, motor and resistive circuits.



This Little Switch Is Big

Ratings range up to 25 A. at 120 or 240 V., and ½, ¾ and 1 hp at 120 V. and 2 hp at 240 V., A.C. U.L. Approved. (Small D.C. ratings also available.) *But base is only* 1½" x 1¼" x ⅞".

This Little Switch Saves Money

Costs less—permits simplification of your designs. Spindle extensible through base to permit ganging of mechanical and electrical controls . . . spade terminals for quick wiring . . . dummy terminals, if required, to eliminate need for blocks.

This Little Switch Is The NEW "Diamond H" Series 390 Rotary

. . . single or double pole, two to twelve positions with stop as required. Single, two-hole or special mounting arrangements. Completely interchangeable with the widely used "Diamond H" Series 240 switches which are still available.

Write today for complete information to meet your requirements

THE HART MANUFACTURING COMPANY

118 BARTHOLOMEW AVE., HARTFORD, CONN.

—ITEM 681—

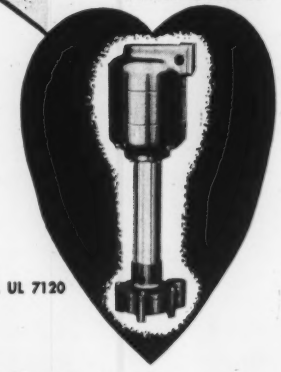
The Heart of a good Coolant System

a **Ruthman GUSHER Coolant Pump**

This 16" Model 280 Springfield Lathe is equipped with a Ruthman "Gusher" Coolant Pump. Photo courtesy Springfield Machine Tool Co.

Yes, a "Gusher" Coolant Pump is truly the heart of a *really good* Coolant System.

A "Gusher" gives you split-second coolant flow without priming. Its simple design eliminates the need for packing, foot or relief valves and it requires less power when throttled. The dynamic balancing of the entire rotating assembly minimizes vibration. The rugged construction with over-sized pre-lubricated ball-bearings reduces attention to a minimum. The result is a *better*, more dependable performance for all "Gusher" Coolant Pumps.



MODEL UL 7120

THE RUTHMAN MACHINERY CO.

1811 Reading Road **Cincinnati, Ohio**

—ITEM 682—

The Engineer's Library

cerned with product finishing. It covers barrel finishing of metal and plastic parts from cleaning and desludging to coloring, polishing and burnishing. Initial chapters cover the operation of finishing compounds and finishing equipment. Most of the book summarizes case histories of tumbling applied to particular parts.

♦

Technical Digests. 8¼ *by* 10½ *inches, paperbound; published by the Organization for European Economic Co-operation; distributed in the U. S. by the O.E.E.C. Mission Publications Office,* 2000 *P Street N.W., Washington* 6, *D. C.*

This new periodical contains reports of current articles selected from about a thousand European journals. The articles describe processes, methods, apparatus and materials which could be applied in industry to increase productivity. A broad range of industrial interests is covered. The first issue is dated Jan. 1956. Subscriptions for one year or six months and single copies are available from the U. S. distributor.

New Standards

Butt-Welded Ends, ASA B16-25-1955. 10 *pages,* 8½ *by* 11 *inches, paperbound; published by and available from the American Society of Mechanical Engineers,* 29 *West* 39*th St., New York* 18, *N. Y.;* $1.00 *per copy.*

This standard covers the preparation of butt-welded ends of pipe, valves, welding neck flanges and pipe fittings. It includes requirements for re-entrant shapes for heavy wall ends, welding bevel profiles, inside contours for joints, and machining dimensions and tolerances.

♦

Letter Symbols for Chemical Engineering, ASA Y10.12-155. 15 *pages,* 8½ *by* 11 *inches, paperbound; published by and available from the American Society of Mechanical Engineers,* 29 *West* 39*th St., New York*

LONGER SOLENOID LIFE...

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Standard or Custom Models

To Fit Your Design

"HardMetal"-welded plunger bonding prevents mushrooming at the vital point of impact—withstands incessant pounding of the plunger on the frame. Long plunger life, and thus long solenoid life, is further insured by hard chrome plating upper guide edges of plunger laminations to reduce friction and wear.

Namco standard solenoids are available in six series of pull and push types; custom-engineered solenoids in every size and type can be made to meet your specifications.

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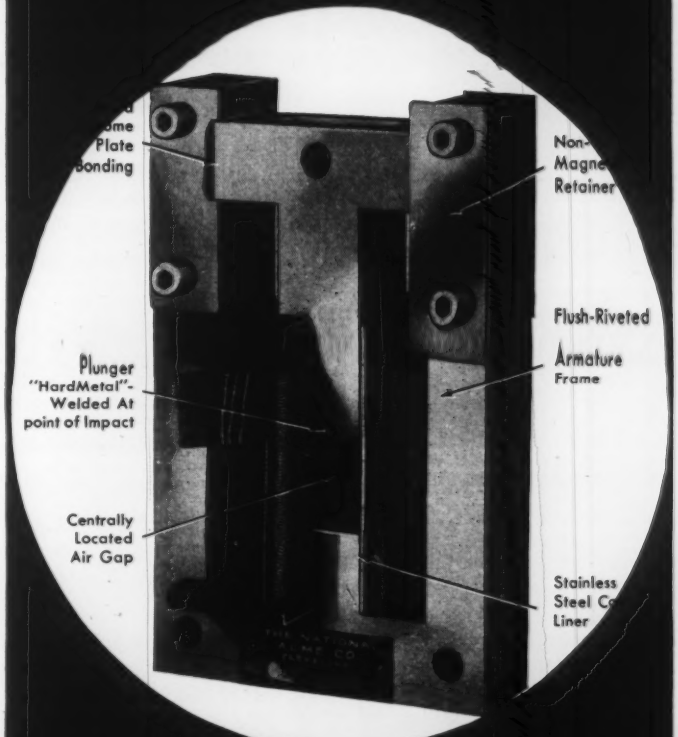
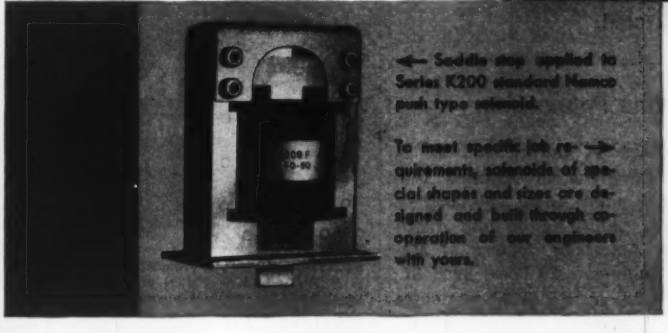
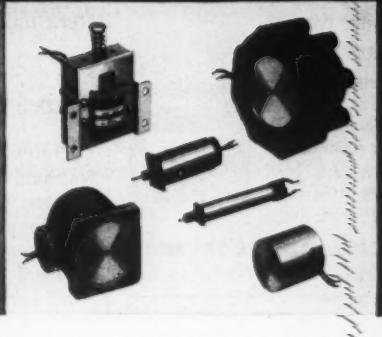




← Saddle step applied to Series K200 standard Namco push type solenoid.

To meet specific job requirements, solenoids of special shapes and sizes are designed and built through cooperation of our engineers with yours. →



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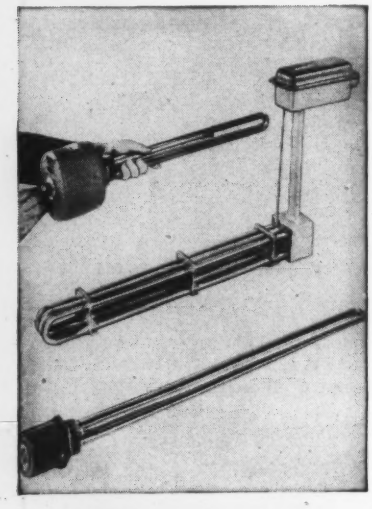

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—ITEM 684—

The Engineer's Library

18, *N. Y.*, $1.00 *per copy.*

This standard supersedes an earlier edition under the same number, dated 1946. The first chapter concerns general principles. The balance of the standard is divided under the headings: general concepts, geometric concepts, intensive properties, symbols for concentrations, symbols for rate concepts and dimensionless numbers.

SAMA Standards. 8½ *by* 11 *inches, paperbound; published by Scientific Apparatus Makers Association,* 20 *North Wacker Drive, Chicago* 6, *Ill.; available without charge from Hampton M. Auld, executive secretary of the association,* 522 *Fifth Ave., New York* 36, *N. Y.; numbers and titles as follows, all approved Oct.* 12, 1955:

RC4-10-1955 **Bimetallic Thermometers** — 3 pages
RC5-10-1955 **Resistance Thermometers** — 3 pages
RC6-10-1955 **Filled System Thermometers**—7 pages
RC7-10-1955 **Glass Stem Industrial Thermometers**—3 pages
RC8-10-1955 **Thermocouple Thermometers**—3 pages

Standards of the SAMA are intended to eliminate misunderstandings between manufacturers and purchasers and to help purchasers select and obtain products for their particular needs. The purpose of all the above standards is to establish uniformity of terminology for the types of thermometers indicated.

Association Publications

Proceedings of the Second U. S. National Congress of Applied Mechanics. 825 *pages,* 8 *by* 11½ *inches, clothbound; published by and available from American Society of Mechanical Engineers,* 29 *West* 39*th St., New York* 18, *N. Y.,* $9.00 *per copy.*

The ninety-nine papers in this book were presented at the meeting held in June 1954 under the sponsorship of the U. S. National Committee on Theoretical and Applied Mechanics. The articles are grouped under the headings (1) general methods, dynamics, vibration and wave motion, (2) elasticity, shells, plates, elastic instability and struc-

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—ITEM 685—

tures, (3) plasticity, viscoelastic flow, failure and behavior of materials, and (4) fluid flow, aerodynamics and heat transfer. National Congresses of Applied Mechanics are held every four years. The first was in 1951.

Government Publications

Handbook on Titanium, WADC Technical Report 54-305. *By Heinrich K. Adenstedt; Part I, PB* 111631, 199 *pages; Part II, PB* 111873, 153 *pages;* 8⅛ *by* 10⅝ *inches, paperbound; published by Wright Air Development Center; available from Office of Technical Services, U. S. Dept. of Commerce, Washington* 25, *D.C.; Vols. I and II,* $3.00 *and* $4.25, *respectively.*

These reports contain evaluated and condensed data collected by literature survey and personal contact. Main sections concern production of titanium and titanium alloys, physical metallurgy of titanium, laboratory procedures, and fabrication of titanium parts.

♦

NACA Technical Series. *Each publication is* 8 *by* 10½ *inches, paperbound, side-stapled, copies available from National Advisory Committee for Aeronautics,* 1924 *F St. N.W., Washington* 25, *D. C.*

The following Technical Memorandums are available:

1385. **On the Gas Dynamics of a Rotating Impeller**—16 pages.

1392. **On the Buckling of Bars and Plates in the Plastic Range**—79 pages.

The following Technical Notes are available:

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3552. **Investigation of the Compressive Strength and Creep Lifetime of 2024-T3 Aluminum-Alloy Plates at Elevated Temperatures**—40 pages.

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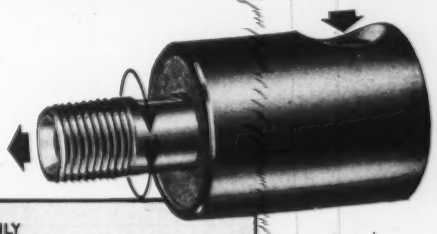
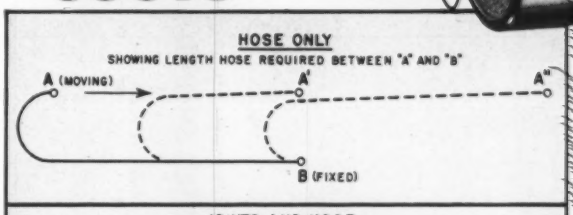
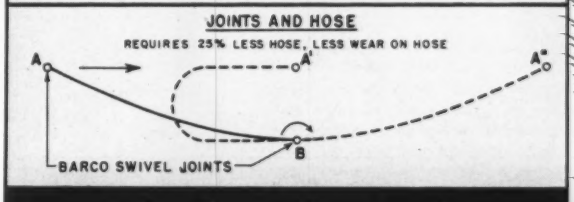
SWIVEL JOINTS

New Barco help cut HOSE COSTS





Straight or Angle Connections



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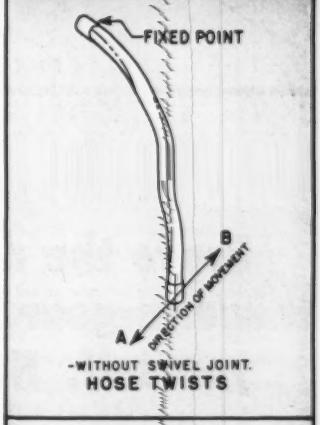

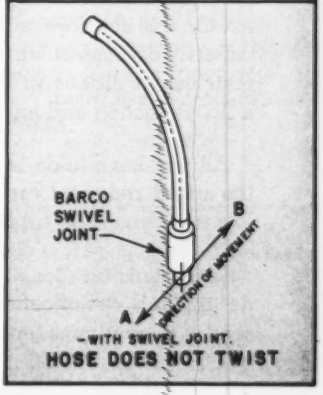

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HERE is a real opportunity for product designers and machinery builders to CUT HOSE COSTS. Barco's new Single Plane Swivel Joints are especially suitable for use as *leakproof* flexible connectors (either angle or straight) wherever hose moves, bends, or twists.

- *Key to Better Engineering!* Often possible to eliminate long radius bends—get neat, space-saving installations (See Fig. 1). Eliminate torsional working stresses that cause fatigue and failure in pressure hose (See Fig. 2).
- *Economical!* These new Barco joints are small, light, and inexpensive. They turn with very low torque under pressure.
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—ITEM 686—

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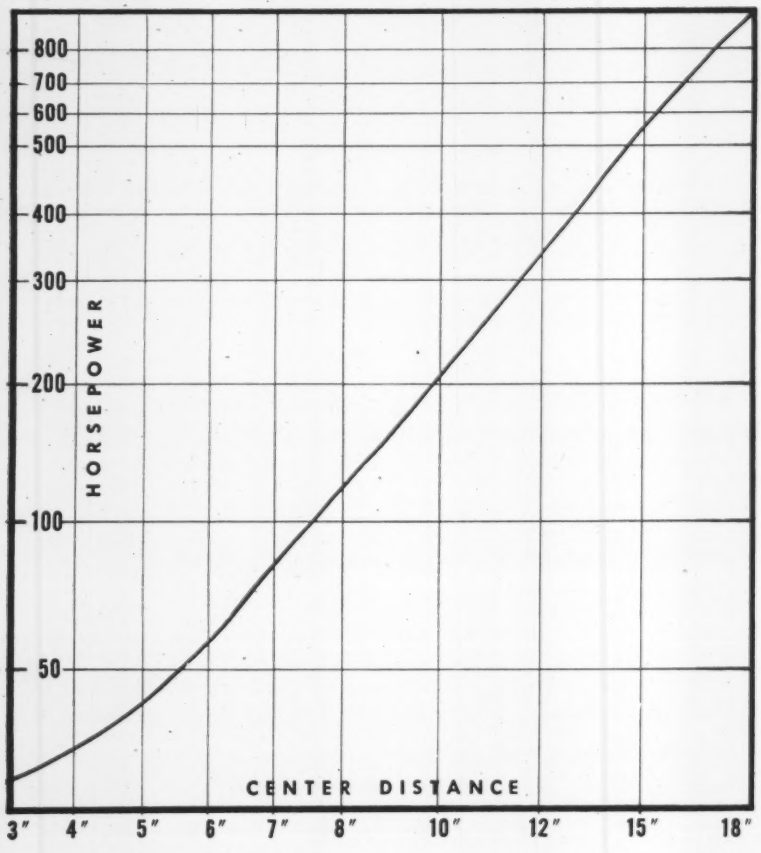


Prove the difference in worm gear speed reducers yourself. Here's how . . .

. . . On this chart we've plotted the mechanical horsepower capacity of Cone-Drive worm gear speed reducers against their center distances. Ratings are for Class I Service with a 5:1 reduction and an input speed of 1750 rpm.

All you have to do is plot the corresponding ratings for the speed reducers you're now using or planning to use. We think you'll be surprised at the results.*

For details on Cone-Drive gearing's double-enveloping design and specifications, ask for Bulletin 600C. We'll send it to you immediately without obligation.

*If you're too busy to "Do-it-yourself", Cone-Drive representatives will be glad to show you filled-in charts.

CONE-DRIVE GEARS
Division, Michigan Tool Company
DOUBLE ENVELOPING GEAR SETS & SPEED REDUCERS
7171 E. McNichols Road • Detroit 12, Michigan

—ITEM 687—
For More Information Circle Item Number on Yellow Card—page 19

New Machines

Materials Handling

Parts Feeder: Model EB-3-B vibratory feeder orients and feeds parts up to 8 in. long in either clockwise or counterclockwise direction. It is equipped with a 36-in. diam bowl. The unit has single or dual discharge to gravity feed tracks for automatically feeding parts to other equipment. Feed rate is regulated by adjusting a rheostat in a separate controller. Parts are discharged from the feed tracks and are regulated by solenoid and air-operated escapement mechanisms. *Syntron Co., Homer City, Pa.*

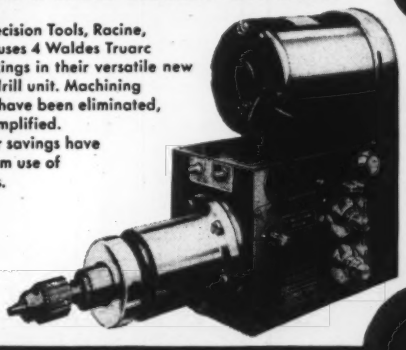
Straddle Type Carrier: Series 93 carrier with 30,000-lb capacity has five-speed synchomesh transmission, hydraulically controlled load hooks and four-wheel steering. Power train components are designed for heavy-duty, high-stress operation. Standard engine is 131 hp; an optional 142-hp engine is available. Road speed with the standard engine is 38.2 mph. Hoist speed is 32 fpm at 2000 engine rpm. Swinging, self-aligning load hooks are 9 ft long. Inside turning radius is 9 ft 7 in. The carrier is available in nine models accommodating loads from 54 to 66 in. high and 52 to 64 in. wide. *Clark Equipment Co., Ross Carrier Div., Benton Harbor, Mich.*

Platform Truck: Electric-powered low-lift platform truck permits the operator to sit during handling operations. It can be built so that the operator faces away from the load, which improves visibility when bulky loads are handled. For frequent load pick-up, or where a direct view of the load platform is required, the truck is built so that the operator faces the platform. Available with capacities from 10,000 to 20,000 lb and with various platform sizes, the truck is equipped with four-wheel steering and hydraulic platform lift. Hydraulic power steering is optional. Battery, gas-elec-

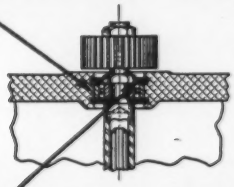
4 Waldes Truarc Rings Cut Costs Drastically, Increase Versatility of Precision Automatic Drill

Dumore's New Automatic Drill

Dumore Precision Tools, Racine, Wisconsin, uses 4 Waldes Truarc Retaining Rings in their versatile new automatic drill unit. Machining operations have been eliminated, assembly simplified. Great labor savings have resulted from use of Truarc rings.

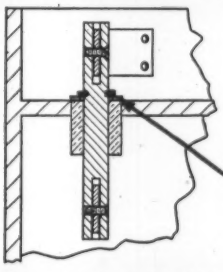


Drive Spindle Assembly



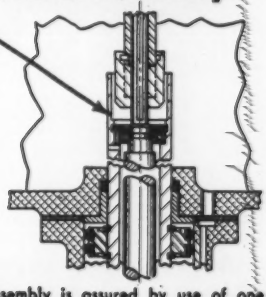
Bearing is held in position by two Waldes Truarc Rings—Standard (Series 5000) and Bowed (Series 5001). Two grooves are turned and housing rough bored in one operation. Alternate method would require at least two additional machining operations. Bowed Truarc ring takes up accumulated tolerances resiliently.

Actuator Lever Shaft Assembly



A Single Waldes Truarc External Retaining Ring (Series 5100) acts as shoulder, holds the lever in position. Labor savings are tremendous—a simple groove cutting operation replaces turning a shoulder, grinding and polishing.

Piston Assembly



Easy assembly is assured by use of one Waldes Truarc Bowed Ring (Series 5001) to lock the bearing to the piston assembly. When unit is to be used in tapping applications, entire spindle assembly can be removed without disassembly.

Whatever you make, there's a Waldes Truarc Retaining Ring designed to improve your product...to save you material, machining and labor costs. They're quick and easy to assemble and disassemble, and they do a better job of holding parts together. Truarc rings are precision engineered and precision made, quality controlled from raw material to finished ring.

36 functionally different types... as many as 97 different sizes within a type...5 metal specifications and 14 different finishes. Truarc rings are available from 90 stocking points throughout the U.S.A. and Canada.

More than 30 engineering-minded factory representatives and 700 field men are available to you on call. Send us your blueprints today...let our Truarc engineers help you solve design, assembly and production problems...without obligation.

For precision internal grooving and undercutting...Waldes Truarc Grooving Tool!

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MD 048

WALDES TRUARC Retaining Rings, Grooving Tools, Pliers, Applicators and Dispensers are protected by one or more of the following U. S. Patents: 2,382,948; 2,411,428; 2,411,761; 2,416,852; 2,420,921; 2,428,341; 2,439,785; 2,441,846; 2,455,165; 2,483,379; 2,483,380; 2,483,383; 2,487,802; 2,487,803; 2,491,306; 2,491,310; 2,509,081; 2,544,631; 2,546,616; 2,547,263; 2,558,704; 2,574,034; 2,577,319; 2,595,787, and other U. S. Patents pending. Equal patent protection established in foreign countries.

—ITEM 688—

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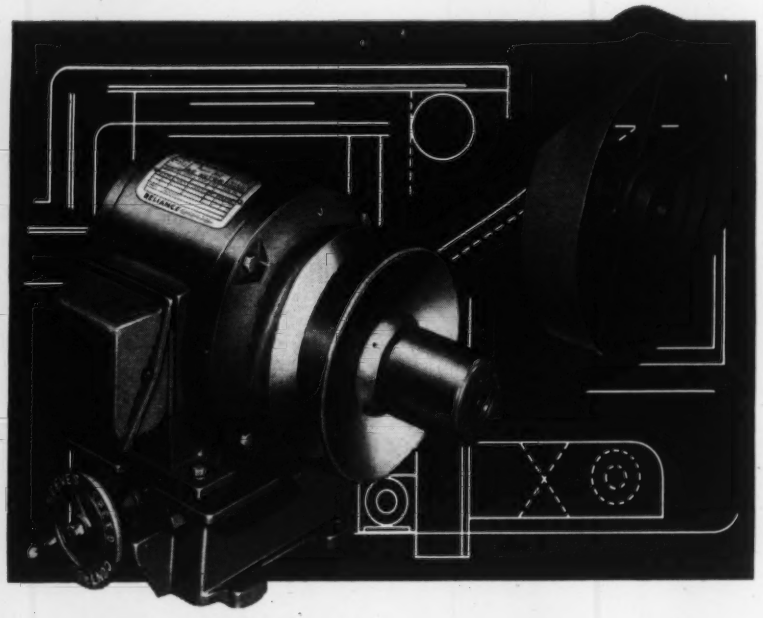

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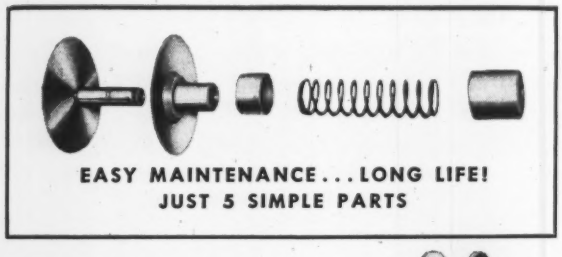

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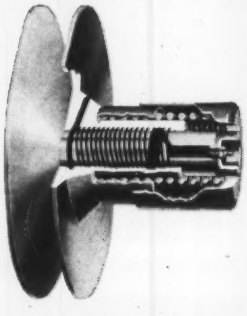


For bulletin complete with rating charts and dimensions, write Dept. H21-V545.

REEVES DIVISION • COLUMBUS, INDIANA

RELIANCE ELECTRIC AND ENGINEERING CO.

New Machines

tric or diesel-electric power can be used. *Elwell-Parker Electric Co., Cleveland.*

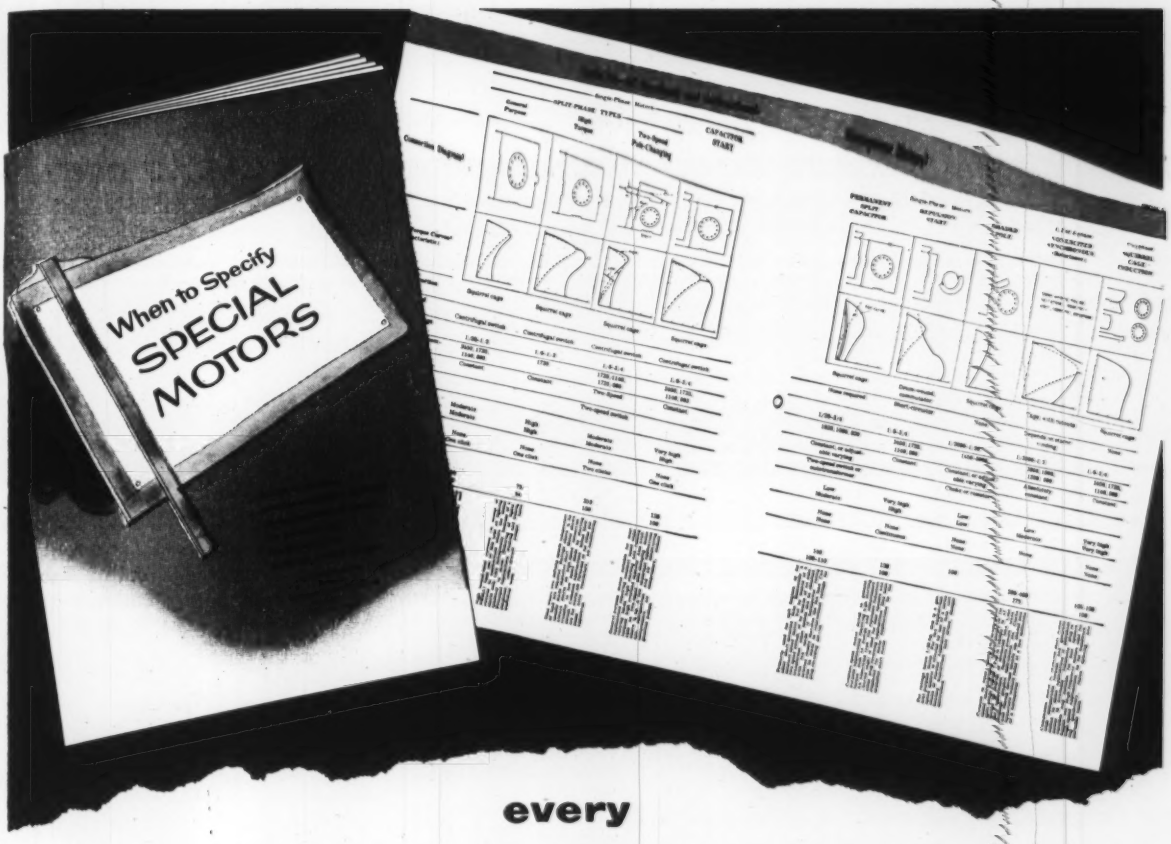
Metalworking

Gear Shaver: Improved GCP 24-in. Red Ring gear shaving machine finishes external and internal spur and helical gears up to 24-in. pitch diam and to 28⅞ in. between centers. It is equipped with rails that permit loading and removing external gears under the shaving cutter. Swivel work head and internal cutter head attachments are provided for shaving internal gears. A hollow spindle in the work head permits the shaving of parts with integral shafts. The machine will shave external gears from 3 to 24-in. pitch diam in the 2 to 16 diametral pitch range. Internal gears from 6 to 24-in. pitch diam in the same tooth size range can be shaved. Rocking table action permits crown shaving. Slide mounting of the cutter head maintains gear working heights over a wide range of gear sizes. Automatic infeed of the work at the end of the stroke, cutter spindle rotation, and table reciprocation are accomplished with separate motor drives. *National Broach & Machine Co., Detroit.*

Profile Miller: No. 50MA machine mills and hand profiles ferrous and nonferrous metals. It is available with tables from 48 x 48 in. to 48 x 144 in. Power feeds for transverse movement, vertical tracing, 360-deg tracing and three-dimensional tracing systems are also available. *Morey Machinery Co. Inc., New York.*

Vertical Chucker: Design of the Acme-Ryder multiple-spindle hydraulic automatic machine is based upon that of Thomas Ryder and Son Ltd., England. Eight-spindle model is equipped with 14-in. capacity chucks, eight turning slides and four cross-slides. The cross-slides can be operated on the vertical turret simultaneously. Independent cross slides, mounted on the lower frame and actuated from cam drums directly beneath them, provide support for heavy forming cuts and cross-facing or necking

—ITEM 689—
For More Information Circle Item Number on Yellow Card—page 19



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3. What modifications are needed?
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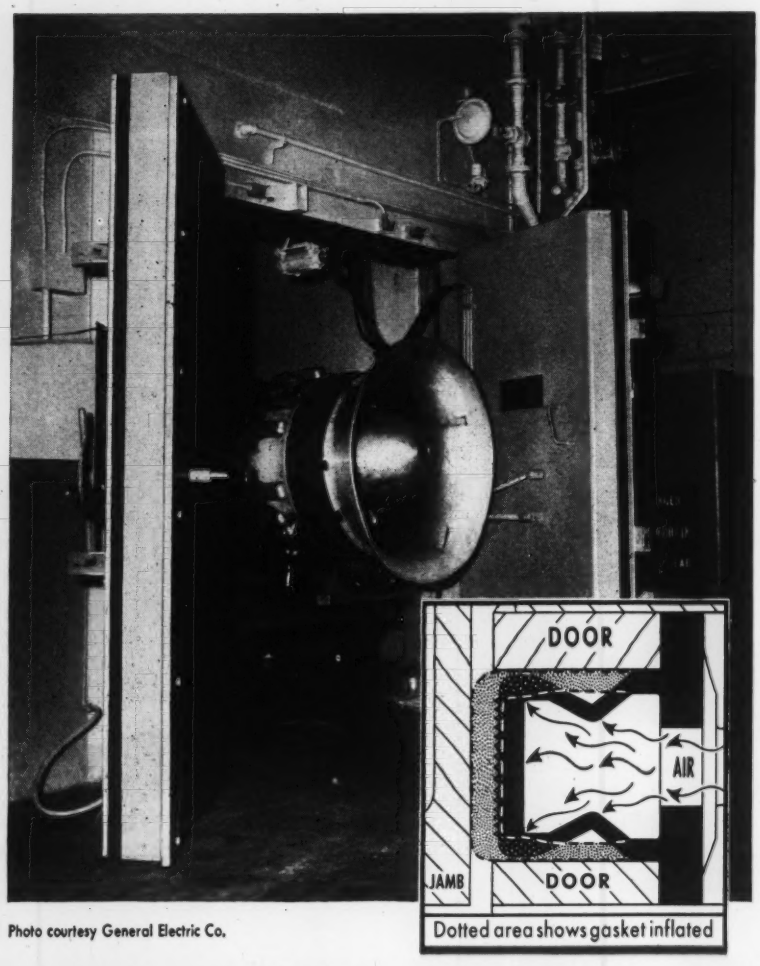


Photo courtesy General Electric Co.

Pneumatic Rubber *Door Seal* Muffles Test Cell Noises

To more effectively suppress noise, General Electric jet engine test cells are equipped with a unique pneumatic rubber door seal. Mounted on door perimeter, this seal is designed to expand proportionally and insure a perfect seal over its entire sealing surface *including the corners*. Not only does this gasket dampen the noise but it permits more accurate testing through quieter working conditions.

Continental engineers developed this pneumatic gasket for this and similar applications. Compounded of special flex-resistant rubber, this versatile gasket can be operated with intermittent flexing cycle *or* as a continuous seal—can be adapted to various other types of doors—for *either* pressure or vacuum rooms.

The design of this gasket typifies the engineering skill offered by Continental. When you need "engineered rubber parts"—molded or extruded—enlist the service of specialists—consult Continental.

Engineering Catalog.

In addition to custom-made parts, Continental offers an extensive line of standard grommets, bushings, bumpers, rings and extruded shapes. Hundreds of these are shown in the No. 100 Engineering Catalog. Send for a copy or refer to it in Sweet's Catalog for Product Designers.

Another achievement in **RUBBER**
engineered by **CONTINENTAL**

CONTINENTAL RUBBER WORKS • 1984 LIBERTY ST. • ERIE 6 • PENNSYLVANIA

—ITEM 691—
For More Information Circle Item Number on Yellow Card—page 19

New Machines

operations. Standard spindle speed range is 32 to 628 rpm. Three speeds are available at each spindle position. Positive indexing of the spindle carrier is provided by an independent indexing motor. Changeover from single to double index is accomplished by the removal or addition of a cam on the indexing tappet shaft. A master timing cam drum controls the automatic machining cycle. *National Acme Co., Cleveland.*

Bayonet Saw: Model 148 heavy-duty machine cuts plastics, ferrous and nonferrous metals, as well as hard and soft woods and plywoods. Saw blades have orbital action in which the blade teeth are in contact only on the cutting stroke and back away on the release stroke. The saw has a 2-in. capacity in wood, ¾-in. in aluminum and ¼-in. in steel. Special base insert eliminates chipping when cutting plywood veneer. The unit permits plunge cuts without drilling starting holes. An accessory base is available for angle cutting. Blower system keeps the line of cut free from sawdust. Heavy-duty, 3½ amp motor cuts at 4250 strokes per minute. The unit is 6¼ in. high and weighs 6 lb. *Porter-Cable Machine Co., Syracuse, N. Y.*

Drilling Unit: Self - enclosed hydraulic feed power unit performs deep hole drilling in alloys to 40 C Rockwell hardness. Drill spindle and pumps are integral and in line with drill thrust. Stroke on the standard unit is 10 in. *Drillmation Co., Hazel Park, Mich.*

Plant Equipment

Vacuum Cleaner: No. 65 heavy-duty unit is designed for industrial cleaning operations. It can remove up to 3¾ gal of liquid or ⅞-bu of dry material before emptying is necessary. Universal 1¼-hp motor is sealed against dirt and water. Two 8-in. rubber wheels and a caster in front permit easy rolling and stability when moving over rough floors. Locking device on the caster holds the machine stationary when desired. Molded Neoprene hose can stretch out in all directions to 15 ft. Machine can be converted to a blower by changing hose connections. Standard attach-

Your choice of normal or low starting current... with Performance-Rated

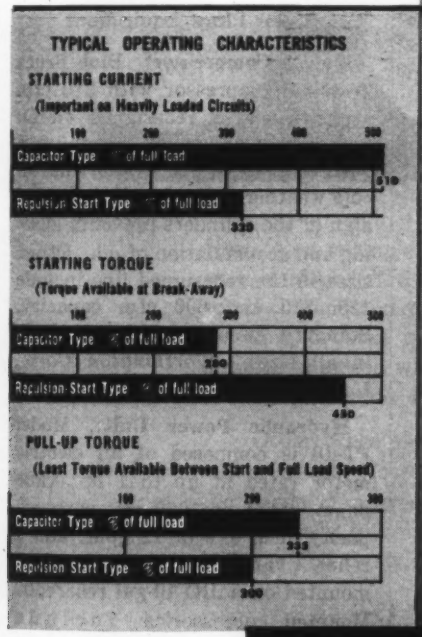
Century

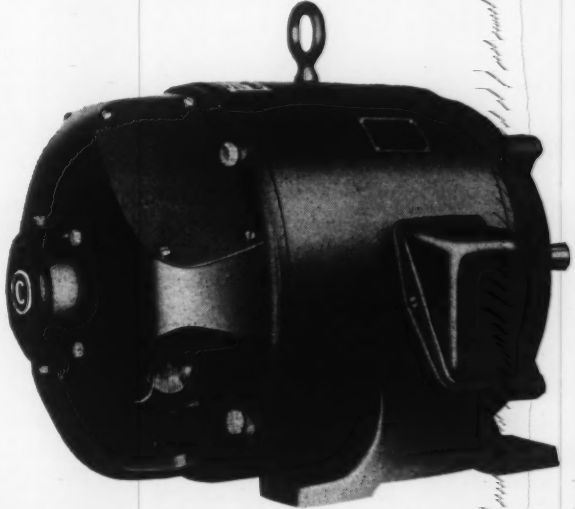
HIGH TORQUE, SINGLE-PHASE MOTORS

Capacitor Motors... ⅛ to 20 H.P. provide high starting torque, high pull-up torque and require normal starting current. They are available in drip proof, dust proof and explosion proof enclosures.

Even if you have severe starting current limitations, you can select the torque you need for sure starts and smooth pull-up to speed from the Century Performance-Rated Single-Phase line (see bar chart below for operating characteristics of two types of Century Single-Phase Motors).

Whatever Your Motor Job . . . there's a Century Motor Performance-Rated to handle it with top effectiveness. Contact your nearby Century branch office or Authorized Distributor.


TYPICAL OPERATING CHARACTERISTICS
STARTING CURRENT
(Important on Heavily Loaded Circuits)
100 200 300 400 500
Capacitor Type % of full load
Repulsion Start Type % of full load
330
STARTING TORQUE
(Torque Available at Break-Away)
100 200 300 400 500
Capacitor Type % of full load
Repulsion Start Type % of full load
450
PULL-UP TORQUE
(Least Torque Available Between Start and Full Load Speed)
100 200 300
Capacitor Type % of full load
Repulsion Start Type % of full load
300



Repulsion Start, Induction Motors (type RS)... ½ to 7½ H.P. provide very high starting torque, yet require unusually low starting current. They are available in drip proof and splash proof enclosures.

Performance-Rated© Motors ⅛ to 400 H.P.

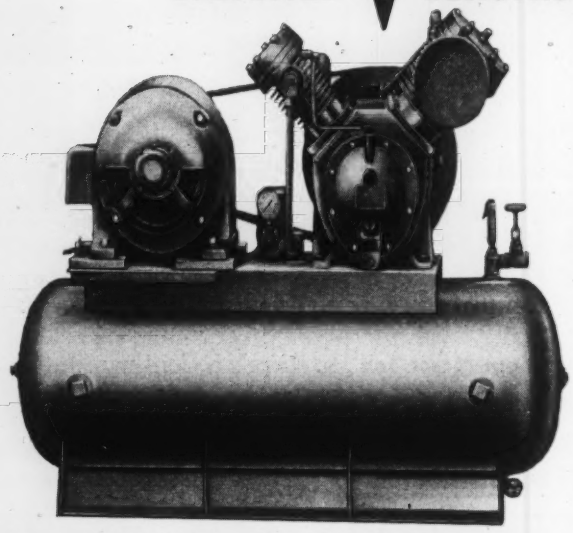
CENTURY ELECTRIC COMPANY

CE-32

1806 Pine Street, St. Louis 3, Missouri • *Offices and Stock Points in Principal Cities*

A good point to consider...

BALANCED V CONSTRUCTION



Why the I-R Air Compressor is right for your product!

WHETHER YOU ARE DESIGNING equipment for your own operation or for resale, there are many points about Ingersoll-Rand's *Balanced V Construction* which will help maintain the quality of your air-powered product. These 3 advantages are typical:

1. **Dependable performance.** The I-R compressor is built to operate reliably, quietly, years longer.

2. **Efficient design.** It delivers more air-per-horse-power, size for size, than other compressors.

3. **Looks like Quality** . . . and it is! Compact, well-constructed, durably built, it carries the name and has the quality plant operators expect.

Get more detailed information on I-R Air Compressors—½ to 20 H.P.—to determine the advantages they bring to your own products. For prompt response, write to:

Ingersoll-Rand

3-352 11 Broadway, New York 4, N. Y.

New Machines

ments include hose swivel, 6-in. nozzle, 6-in. brush and crevice tool. Weight of the cleaner is 56 lb; it is 34¼ in. high and has an outside diameter of 19 in. *Black & Decker Mfg. Co., Towson, Md.*

Road Sweeper: Self-propelled SP-C machine, a combination of prime mover and rotary brush assembly, sweeps dirt, trash, rock, snow and other materials from even surfaces. The prime mover has a heavy-duty, 48-hp engine which is water-cooled and electrically started. Transmission is four-speed, automotive type. Removable brush is adjustable for ground pressure and is powered by a 7-hp air-cooled engine. Brushes are available in 6, 7, and 8-ft lengths. Rear-wheel steering and a short wheelbase permit nonstop turns on standard roadbeds. Speeds up to 40 mph are possible for travel between jobs. The machine is 4 ft 3 in. high and 11 ft 6 in. long. Optional equipment for the sweeper includes a water-sprinkling system, front deflector and steel bristle broom. *Little Giant Products Inc., Peoria, Ill.*

Power Plant Equipment

Rotary Compressor: Blue Brute portable compressor with 210 cfm capacity has a redesigned clutch and separate oil reservoir equipped with a preheater for starting in cold weather. Gravity-draining design of the cylinders prevents locking and accumulation of oil. Other sizes in the redesigned line include 125, 315 and 600 cfm capacity. Standard mountings are available in all sizes. *Worthington Corp., Harrison, N. J.*

Hydraulic Power Unit: Model PT-10 is composed of an electric motor rated at up to 1 hp; vane pump, rated at 1000 psi, with capacity of 3, 6, 9 or 12 gpm; and a relief valve. Components are mounted on a JIC 10-gal reservoir. Mounted accessories include breather, filler cap and screen, oil level gage, baffles and three circuit return ports. *Rosaen Co., St. Clair Shores, Mich.*

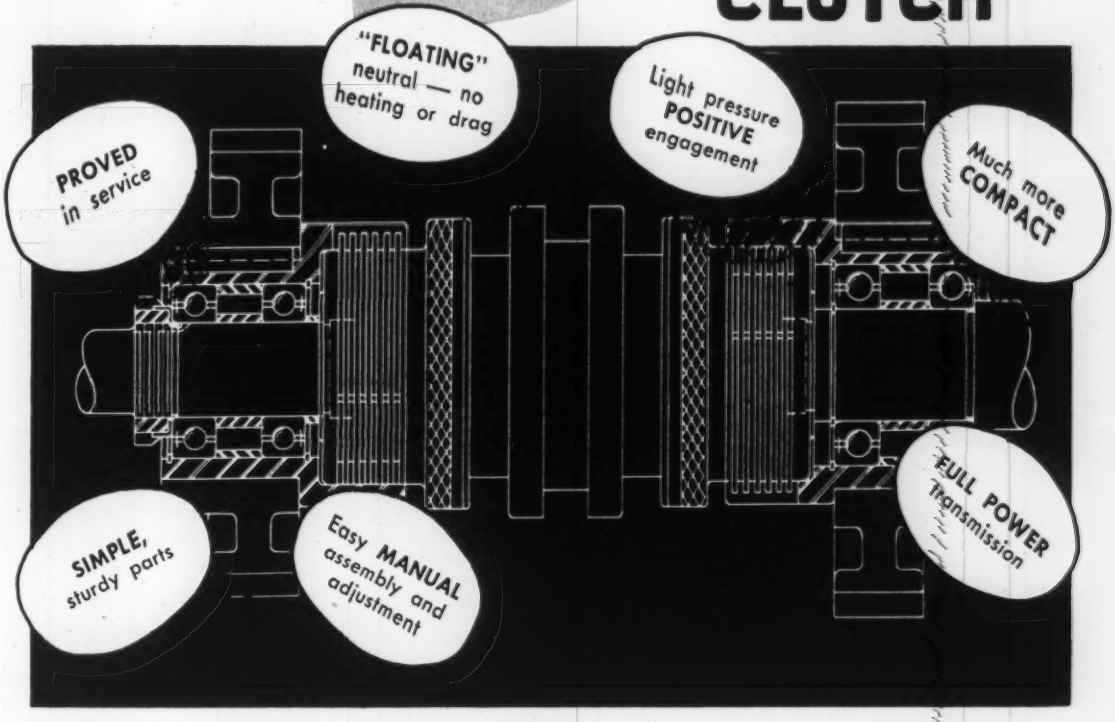
Electric Plants: Models 305CCK and 5CCK electric generating plants are available in 3500 and

BUILD INTO YOUR PRODUCT THE TROUBLE-FREE PERFORMANCE OF A

MAXITORQ

floating disc

CLUTCH


"FLOATING" neutral — no heating or drag
Light pressure POSITIVE engagement
PROVED in service
Much more COMPACT
SIMPLE, sturdy parts
Easy MANUAL assembly and adjustment
FULL POWER transmission

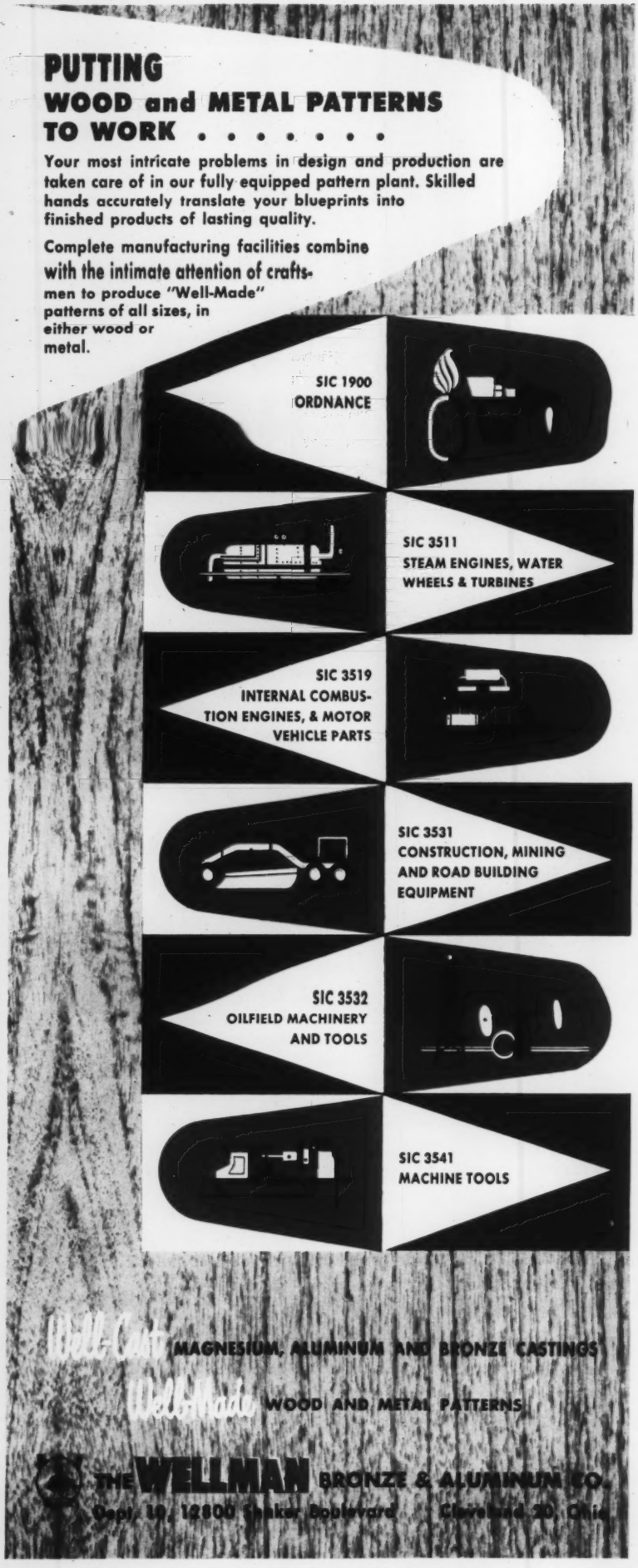
Here is an example of the simple, rugged, and compact installation possible with a MAXITORQ Double Clutch, with pulley-type driving cups, as the speed-change control between high and low-speed gears. Since MAXITORQ clutches, because of their exclusive design features, are always quick and positive in action while at the same time completely free in neutral, this type of installation has a well-proved record of performance to recommend it.

Other types of MAXITORQ Floating Disc Clutches . . . single, double, and overload release . . . are available in a wide range of stock sizes to meet the needs of a great many installations. Our engineering department also stands ready to help you with special drive problems. Write or phone Dept. MD-4. The Carlyle Johnson Machine Company, Manchester, Conn.

Let's talk **MAXITORQ**

—ITEM 694—

For More Information Circle Item Number on Yellow Card—page 19


PUTTING
WOOD and METAL PATTERNS
TO WORK . . . . . .
Your most intricate problems in design and production are taken care of in our fully equipped pattern plant. Skilled hands accurately translate your blueprints into finished products of lasting quality.
Complete manufacturing facilities combine with the intimate attention of craftsmen to produce "Well-Made" patterns of all sizes, in either wood or metal.
SIC 1900
ORDNANCE
SIC 3511
STEAM ENGINES, WATER WHEELS & TURBINES
SIC 3519
INTERNAL COMBUSTION ENGINES, & MOTOR VEHICLE PARTS
SIC 3531
CONSTRUCTION, MINING AND ROAD BUILDING EQUIPMENT
SIC 3532
OILFIELD MACHINERY AND TOOLS
SIC 3541
MACHINE TOOLS
MAGNESIUM, ALUMINUM AND BRONZE CASTINGS
WOOD AND METAL PATTERNS
THE WELLMAN BRONZE & ALUMINUM CO.
Dept. 19, 12800 Shaker Boulevard Cleveland 20, Ohio
—ITEM 695—

New Machines

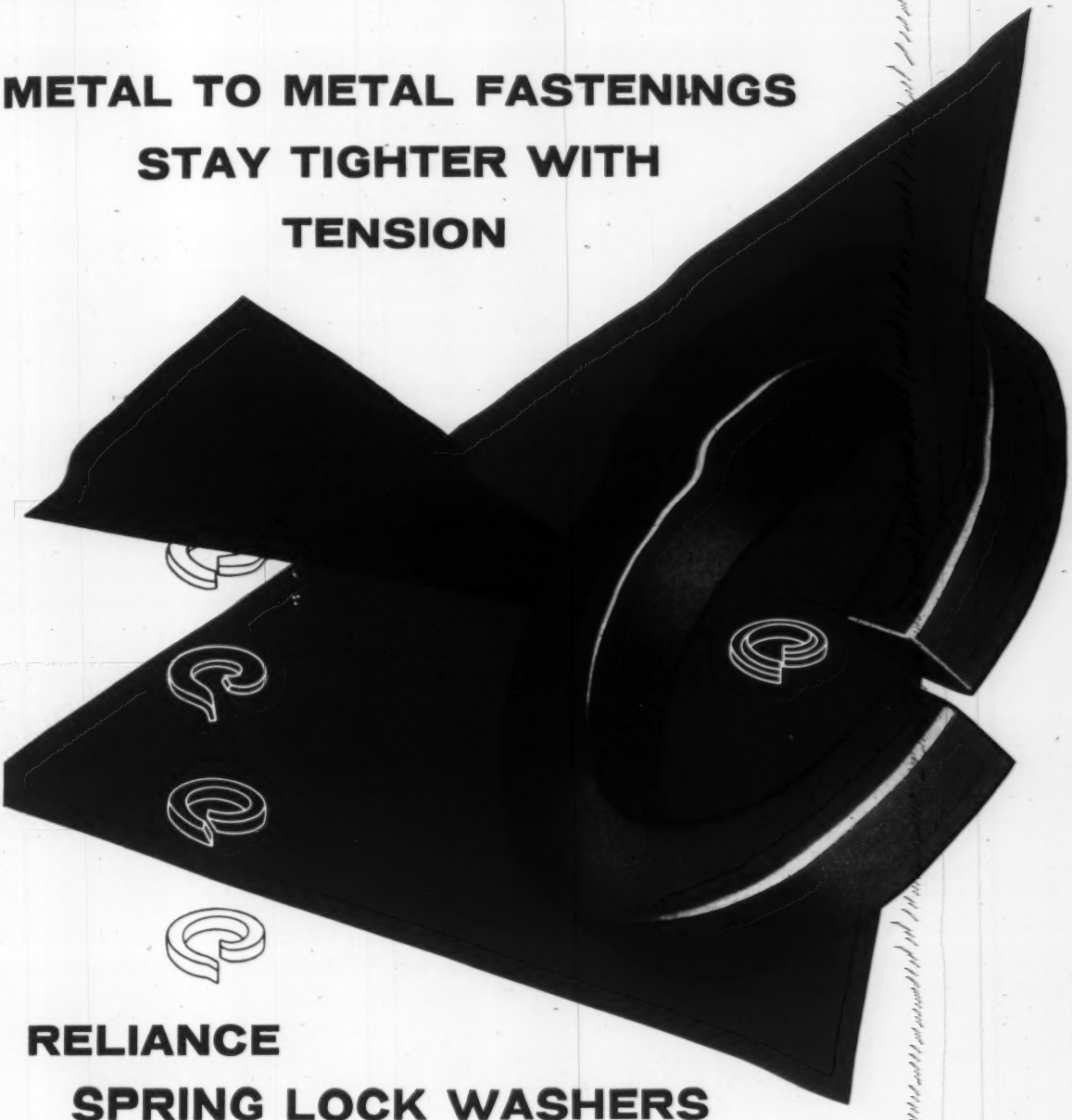
5000-w ac sizes. Both models are powered by 2-cylinder, 4-cycle, air-cooled gasoline engines. Opposed cylinder design provides quiet performance. Both series are made for 60 or 50-cycle, 115, 230 or 115/-230-v, single phase, or 230-v, 3-phase, 3-wire operation. Standard remote control, portable or manual-starting models are available. The generators are directly connected to the engines for permanent alignment. *D. W. Onan & Sons Inc., Minneapolis.*

Processing

Marking Unit: Hydraulic machine is designed for operation on automated production lines. The machine receives a signal from a master control panel and from the workpiece in the station. It clamps and marks the workpiece, indexes the numbering head, unclamps, and records information on a continuous paper tape. The cycle takes 8 seconds. A signal is then transmitted to the control panel, the workpiece is moved out of its station, and another work cycle begins. The unit is equipped with a universal mounting plate for installation in any position. *Cadillac Stamp Co., Detroit.*

Laminating Press: Wring-Master rotary unit bonds materials such as high-pressure plastic laminates, vinyl and linoleum to plywood, metal and other firm backings. It also laminates three-ply constructions with honeycomb paper cores and laminates steel to plywood. The press has a positive nip adjustment for precise setting of pressure roll gap for panel thickness up to 5 in. Panels are automatically pulled through the press at speeds from 15 to 30 fpm. Stabilizing roll mounted immediately behind the nip prevents fluttering of rigid panels. Rolls are covered with heat-resistant Neoprene. The machine can accommodate loads up to 8000 lb with 8-in. diam pneumatic cylinders. For a 48 in. wide panel, the load is 150 lb psi. For panels up to 60 in. the same unit loading can be had by substituting 9-in. diam cylinders, increasing load capacity to 10,000 lb. *Rodney Hunt Machine Co., Orange, Mass.*

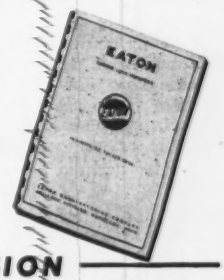
METAL TO METAL FASTENINGS STAY TIGHTER WITH TENSION



RELIANCE SPRING LOCK WASHERS

Metal products assembled by the tried and true nut/bolt method need more than just tight fastenings at the end of the production line. This especially is true of products subject to movement, vibration, stresses and strains. Metal wears, bolts stretch; and a fastening can become loose even though the nut doesn't turn. One solution to this problem is the application of constant tension to the assembly supplied by Reliance Helical Coil Spring Lock Washers.

These are the same high quality Spring Lock Washers on which the metal working industry has depended for forty-two years. They are made of cold drawn spring steel and are quality controlled throughout the manufacturing operation. For the complete story, write for your free copy of Reliance Engineering Bulletin W-50.



EATON

RELIANCE DIVISION

MANUFACTURING COMPANY

506 CHARLES AVENUE • MASSILLON, OHIO

SALES OFFICES: New York • Cleveland • Detroit • Chicago • St. Louis • San Francisco • Montreal

PRODUCTS: Sodium Cooled, Poppet, and Free Valves • Tappets • Hydraulic Valve Lifters • Valve Seat Inserts • Jet Engine Parts • Rotor Pumps • Motor Truck Axles • Permanent Mold Gray Iron Castings • Heater-Defroster Units • Snap Rings Springtites • Spring Washers • Cold Drawn Steel • Stampings • Leaf and Coil Springs • Dynamatic Drives, Brakes, Dynamometers

—ITEM 696—

let Stalwart show you how SILICONE RUBBER can cut fabrication costs!

Industry across-the-board is solving problems, and *cutting costs*, with Silicone Rubber Parts. From access door seals on research rocket planes probing the heat barrier . . . to gaskets for kitchen range oven doors, they are providing the answer. Time and again Silicone Rubber Parts are replacing costly metal constructions forced upon design engineers by the limited thermal stability of organic rubbers.

Because new compounds now retain desirable rubber-like properties at temperatures from −130°F. to +600°F., they play ever-increasing roles in the aviation, automotive, electrical and chemical industries.

STALWART is equipped to produce precision parts from a variety of Silicone Stocks to meet individual, S.A.E., MIL-G or MIL-R specifications.

Parts made from Silicone have excellent dielectric properties and resist compression set, weathering, ozone, oxidation, hot lubricating oils and many chemicals. They can be covered with (or bonded to) a number of synthetic or other materials to provide greater strength or wearing qualities. Let STALWART show you how Silicon Rubber can *cut* your fabrication costs.

6651-SR

STALWART RUBBER COMPANY

180 Northfield Road Bedford, Ohio

For complete information, write today for Catalog 56SR-3

—ITEM 697—

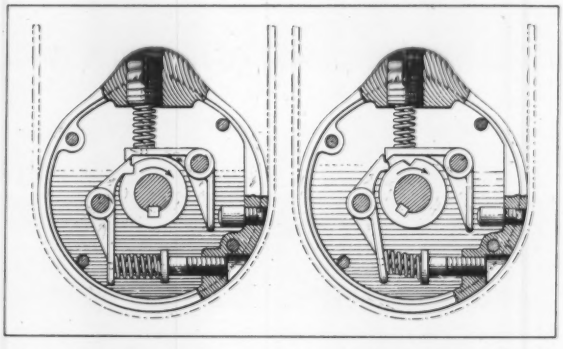
NOTEWORTHY Patents

Low-Friction Shaft Seal

Friction drag usually encountered in fluid seals for instrument use is minimized by a design which eliminates relative motion between O-rings and adjacent metal parts. Seal faces are a mirror finish to further minimize friction forces. A helical spring maintains pressure of sealing engagement. *Patent 2,712,461 assigned to Rockwell Mfg. Co. by G. E. Batchelder.*

Overload Clutch

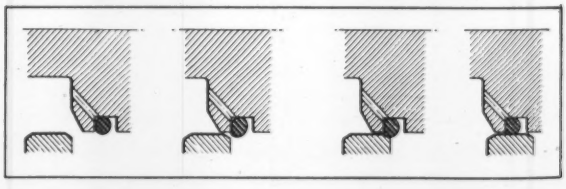
Overload protection is provided for either direction of drive shaft rotation by a release mechanism consisting of a driven pivoted pawl and a notched drive collar. A detent at the free end of the pawl is held in the notch by a helical spring. Upon overload the

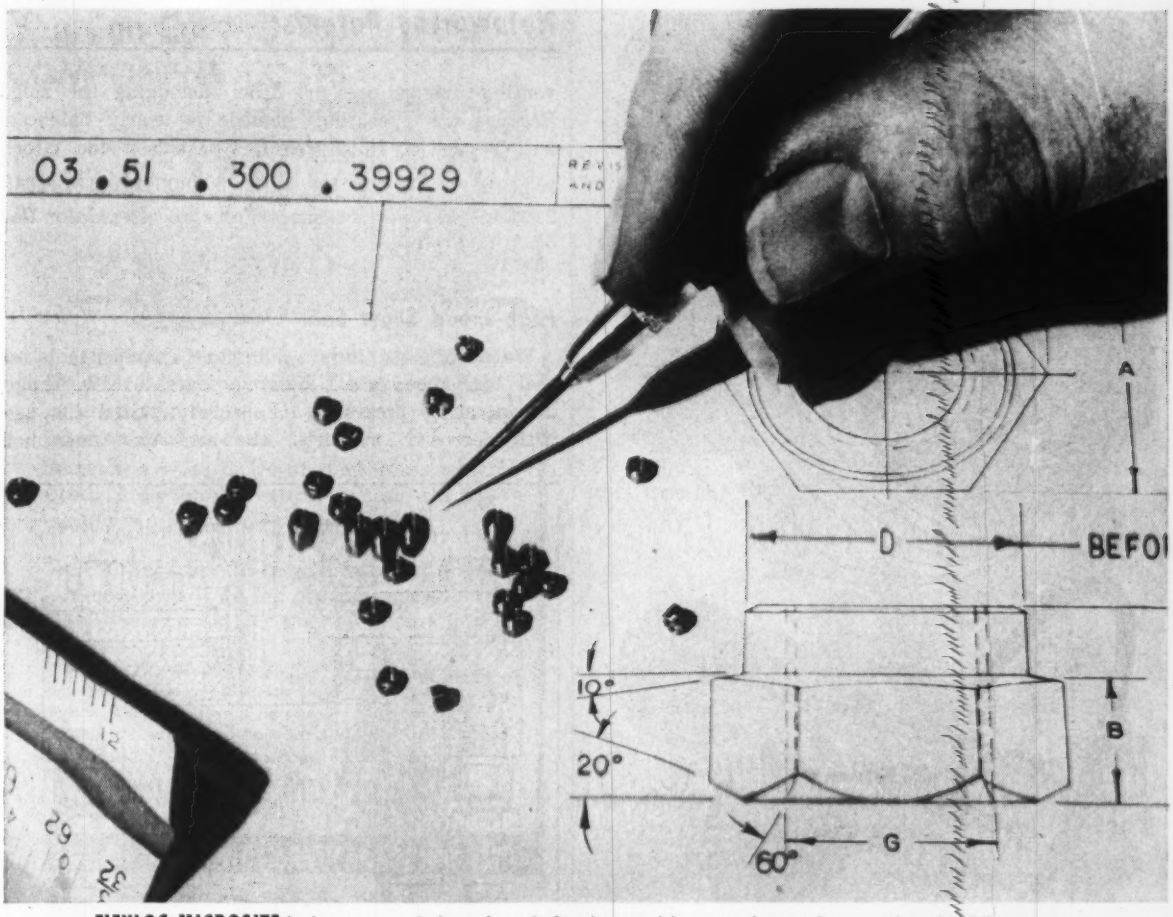


detent is forced out of the notch releasing the clutch. When this occurs, a second pawl which is also part of the driven element locks the first pawl against re-engaging until a reset screw can be operated manually. An electrical switch, operated by the movement of the pawls, can be incorporated in the system to turn off the drive motor. *Patent 2,713,406 assigned to Centric Clutch Co. by M. K. Babaian.*

Pressure-Sensitive Valve Seal

High-pressure fluid flow is effectively controlled by a valve using a small O-ring as sealing element. Design of the O-ring assembly enables the fluid pressure to apply additional sealing force. Pressure behind the O-ring is relieved by a small duct, pre-





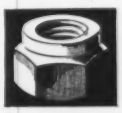
FLEXLOC MICROSIZE locknuts meet designers' needs for tiny precision nuts that retain strength and holding power in the smallest assemblies—servomechanisms, electronic and electrical equipment, all miniature devices.

Design Lighter, More Compact Products with New FLEXLOC Microsize Locknuts

Standard Microsize Locknuts Permit Design Engineers to Develop and Fasten Smaller Assemblies Safely

SIZE	Across Flats		Shoulder Height		Across Corners	Height +.000 −.003
	MAX.	MIN.	MAX.	MIN.	MIN.	
0-80 NF-3B	.111	.107	.047	.042	.123	.075
1-64 NC-3B	.127	.123	.0635	.0585	.141	.090
1-72 NF-3B	.127	.123	.0635	.0585	.141	.090
2-56 NC-3B	.158	.153	.068	.063	.176	.105
2-64 NF-3B	.158	.153	.068	.063	.176	.105
3-48 NC-3B	.190	.183	.071	.066	.210	.120
3-56 NF-3B	.190	.183	.071	.066	.210	.120
4-40 NC-3B	.190	.183	.072	.067	.210	.120
4-48 NF-3B	.190	.183	.072	.067	.210	.120

STANDARD MICROSIZE FLEXLOCs—in sizes ranging from 0-80 to 4-48—are available in brass (either plain or cadmium plated). Consult SPS for miniature nuts of other conventional materials.



New FLEXLOC Microsize locknuts are smaller and lighter than regular FLEXLOCs of the same nominal diameter. Wrenches of smaller size are used to install them. Mating joints or flanges can be designed smaller—with no loss in strength or convenience of assembly.

Microsize FLEXLOCs have all the advantages of larger FLEXLOCs. One-piece, all-metal construction—nothing to put together, come apart, lose or forget. Use them as lock or stop nuts—they stay put anywhere on a threaded member as soon as the locking threads are fully engaged. Uniform locking torques insure accurate preloading. There are no nonmetallic inserts to pop out or deteriorate. Moisture, dryness, oil, temperatures to 250°F won't affect these Microsize FLEXLOCs. Just screw them on. They lock and stay locked. Vibration won't shake them loose.

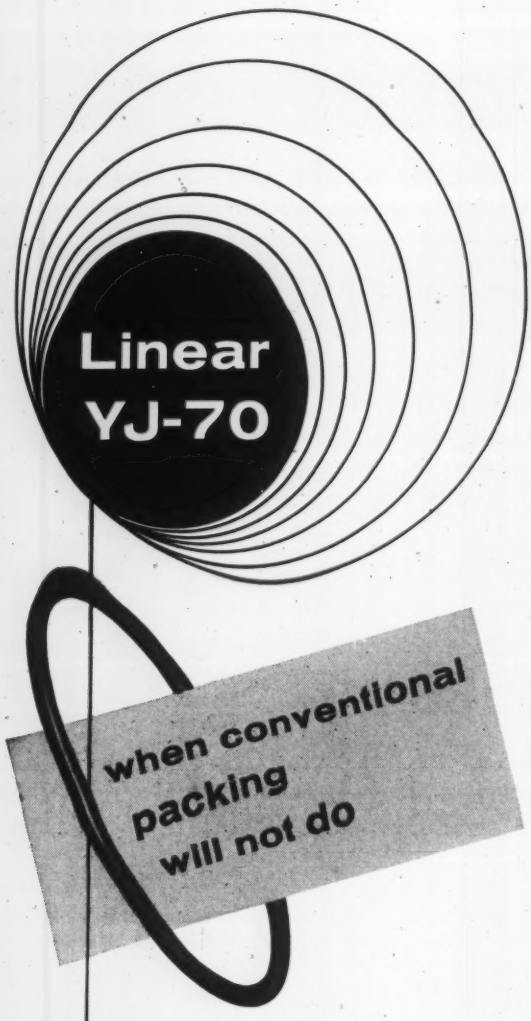
For complete information on Microsize FLEXLOCs, consult your authorized SPS distributor. Or write STANDARD PRESSED STEEL CO., Jenkintown 18, Pa.

STANDARD PRESSED STEEL CO.

FLEXLOC LOCKNUT DIVISION **SPS**

JENKINTOWN PENNSYLVANIA

—ITEM 698—



Conversion from flammable to non-flammable fluids has created serious packing problems in many hydraulic systems. Ordinary molded seals deteriorate rapidly when non-inflammable fluids are used in the system.

Pioneer research by LINEAR has developed Compound YJ-70 to solve this problem. YJ-70 is not affected by *Skydrol, Pydraul, Lindol* or mediums that contain *Tri-Cresyl-Phosphate*—provides perfect sealing in systems using these and other diester fluids. At the same time, YJ-70 withstands deterioration and maintains dimensional stability in the usual flammable petroleum base fluids.

This dual compatibility makes packing change over unnecessary . . . no down time for packing replacement . . . assures perfect sealing under all conditions.

Here is another example of LINEAR leadership. Whatever your packing problem, it will pay you to look to LINEAR.

"PERFECTLY ENGINEERED PACKINGS"

LINEAR

LINEAR, Inc., STATE ROAD & LEVICK ST., PHILADELPHIA 35, PA

—ITEM 699—

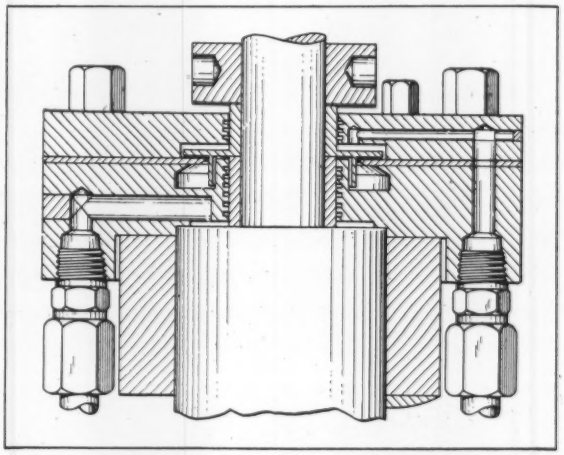
For More Information Circle Item Number on Yellow Card—page 19

Noteworthy Patents

venting reverse pressure from dislodging the ring. Because the operating member is nearly balanced with respect to fluid pressures on either side, effort required to operate the valve is minimized. *Patent 2,713,989 assigned to Grove Valve and Regulator Co. by A. U. Bryant.*

High-Speed Shaft Seal

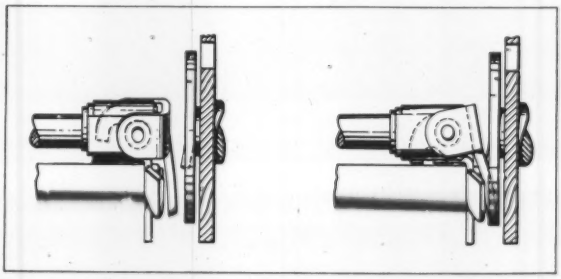
Water injected into a lubricant chamber acts to seal high-speed shaft bearings over a wide range of operating pressures. Especially suited for use with corrosive mixtures, the seal unit does not



require precision machined bearing surfaces. Water pressure can be increased to accomodate higher operating pressures. *Patent 2,714,045 assigned to Dow Chemical Co. by L. O. Simenson.*

One-Way Clutch

A pivoted pawl, rotating with the drive shaft, engages a recess or pocket in a disk on the output member to provide a one-way clutching action. Tilting the driving pawl to disengage the clutch is accomplished by a control shaft. Two clutches of this type may



be used together to actuate two shafts, rotating in opposite directions. An arm arrangement permits only one of the clutches to be engaged at any time. *Patent 2,712,866 assigned to Friden Calculating Machine Co. by R. G. Lelata.*

Copies of patents briefed in this department may be obtained for 25 cents each from The Commissioner of Patents, Washington 25, D. C.

You Can Cut MOTOR COMPONENT COSTS

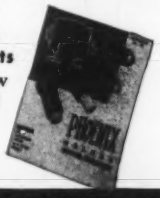
with **PHOENIX** *Brush Holders*

PHOENIX Molded or Assembled Motor Brush Holders are custom-designed to your exact specifications—yet delivered to you at mass production costs!

Secret is a wide range of stock tools which produce an infinite variety of uniform top-quality, close-tolerance brush holders.

Take a hint from the large number of manufacturers already saving on component costs with Phoenix . . . Get the full details now!

SEND FOR CATALOG 56L
Shortcut to Lower Production Costs
New Phoenix Catalog shows how to order customized standard brush holders to fit your needs. Free on request.



PHOENIX ELECTRIC MANUFACTURING CO.
4211 West Lake Street Chicago 24, Illinois
—ITEM 700—

"MONOBALL" Self-Aligning Bearings

PATENTED-U.S.A.
All World Rights Reserved

CHARACTERISTICS

	ANALYSIS	RECOMMENDED USE
1	Stainless Steel Ball and Race	For types operating under high temperature (800-1200 degrees F.).
2	Chrome Moly Steel Ball and Race	For types operating under high radial ultimate loads (3000-893,000 lbs.).
3	Bronze Race and Chrome Moly Steel Ball	For types operating under normal loads with minimum friction requirements.

Thousands in use. Backed by years of service life. Wide variety of Plain Types in bore sizes 3/16" to 6" Dia. Rod end types in similar size range with externally or internally threaded shanks. Our Engineers welcome an opportunity of studying individual requirements and prescribing a type or types which will serve under your demanding conditions. Southwest can design special types to fit individual specifications. As a result of thorough study of different operating conditions, various steel alloys have been used to meet specific needs. Write for revised Engineering Manual describing complete line. Address Dept. MD-56.

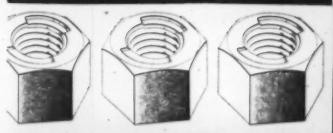
SOUTHWEST PRODUCTS CO.
DUARTE, CALIFORNIA
—ITEM 702—

M·F HOLDS THE LINE!

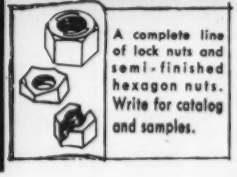
CONSTANT TORQUE NUT-BY-NUT KEG-BY-KEG MEANS A SMOOTH-RUNNING PRODUCTION LINE

Here's *rhythm* for your production line! SET YOUR AIR-WRENCH, SET YOUR TEMPO—and *keep it up*, keg after keg!

Constant torque means fewer rejects, too—because equalized bolt tension keeps your product true to original design. (Check a batch of your present lock nuts for torque *consistency*, nut-by-nut . . . it means everything when *bolt-tension* is a design factor.)



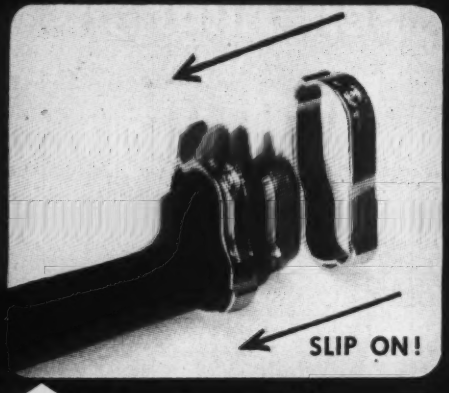
MAC LEAN-FOGG
Lock Nut Company
5535 N. Wolcott Street
Chicago 40, Illinois



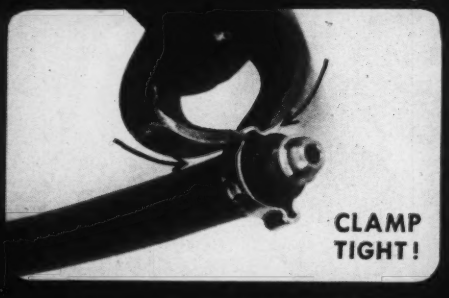
A complete line of lock nuts and semi-finished hexagon nuts. Write for catalog and samples.

—ITEM 701—

NEW CIRCLE HOSE CLAMPS



ON IN 2 SECONDS . . .



OFF IN 1 SECOND!

Best Clamping Action Available

A new idea that gives you lower initial cost, easy field installation and dismounting. Available in a wide range of sizes to accommodate all hose variations.

Write for complete descriptive information, stock sizes, prices and the name of your nearby Circle Clamp Distributor.

Circle Clamp Corporation
39 Broadway, New York 6, N.Y.

—ITEM 703—

Efficient engineering and drafting departments use VEMCO drafting machines

because of such features as these:

Automatic indexing for rapid settings.
Resilient scale chucks to insure firm grip.
Flexible, for speedy free movement.
VEMCO Versatilt provides easy floating motion on tilted boards.

VEMCO

See your VEMCO dealer or write:

V. & E. Manufacturing Co.
Department AM-2
P.O. BOX 950-M • PASADENA, CALIFORNIA

—ITEM 704—

VULCAN
ELECTRIC HEATING UNITS

Coils of Heat

Tubular Electric Heating Units that fit around or clamp to vessels, tanks, pipes, etc., for contact heating of metals, oils, water and air.
. . . especially where little space is available and considerable heat is needed.

STANDARD SIZES or made to your requirements

VULCAN ELECTRIC COMPANY
DANVERS 6, MASS.

EXPERIENCED SPECIALISTS IN ELECTRIC HEAT
Makers of Vulcan Electric Soldering Tools, Electric Solder Pots, Electric Branding Irons, Electric Heating Units, and Electric Heating Devices.
See 8-page Vulcan catalog in Sweet's Product Design File for 1955

—ITEM 705—

you need MOLYKOTE® Lubricants

IF YOU HAVE LUBRICATION PROBLEMS IN THESE APPLICATIONS

CHECK OFF THE ONES WHICH ARE GIVING YOU TROUBLE

- ☐ EXTREME BEARING PRESSURES
- ☐ EXTREME TEMPERATURES
- ☐ UNUSUAL ENVIRONMENT
- ☐ MATING SURFACES OF SAME OR SIMILAR MATERIALS
- ☐ FRETTING
- ☐ HIGH STARTING FRICTION
- ☐ RUBBER ON METAL
- ☐ LIFETIME LUBRICATION
- ☐ RESISTANCE TO CENTRIFUGAL FORCE

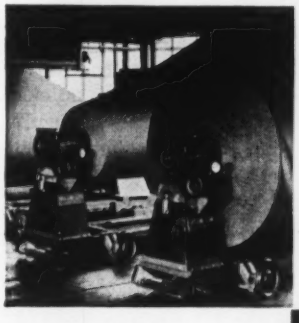
Even if you have checked only one of these sources of lubrication problems, you need MOLYKOTE. Tell us which ones you have checked and we will mail you pertinent literature.

The ALPHA MOLYKOTE Corporation
Main Factories: 67 Harvard Avenue, Stamford, Conn.
71 Arnulfstrasse, Munich 19, Germany

—ITEM 706—

TENSION CONTROL ON PAPER MILL ROLLS

Wagner Actuating system and brakes maintain easily adjusted uniform tension



Wagner Industrial Drag Brakes on the paper mill roll stand shown here, keep constant tension on the roll as paper is fed out to other machinery. Brakes are actuated by a Wagner control cylinder, which is operated by a hand wheel. A Wagner Type H Brake, of the type shown below, is used in this application.

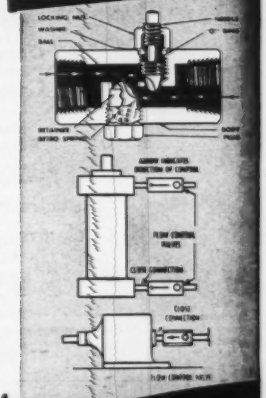
For *your* specific applications, Wagner can furnish engineered kits with actuators, controls, tubing, fittings—everything required for complete installation. Your nearby Wagner field engineer will get you detailed specifications on a system for your particular application. Call him today.

Wagner Electric Corporation
6404 PLYMOUTH AVE., ST. LOUIS 14, MO. 156-1

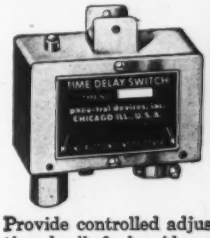
—ITEM 707—

For Precise SPEED and TIME DELAY CONTROL OF AIR OR HYDRAULIC CYLINDERS

USE **Pneu-trol** VALVES and TIME DELAY CONTROL SWITCHES

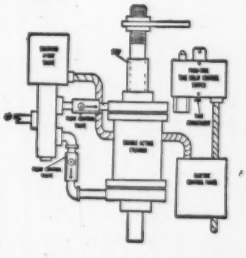


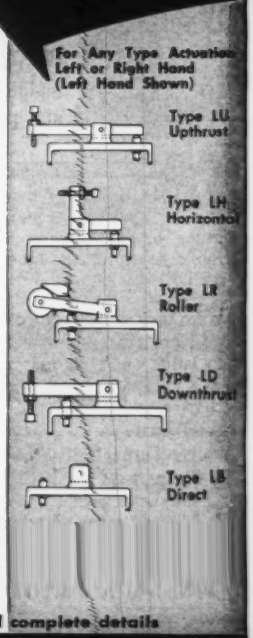
Pneu-Trol Valves combine in a short, compact body, a tapered fine thread needle for extremely accurate air or oil flow control and a floating retro ball check, which permits full flow in the opposite direction. Retro ball floats in most sensitive position to seat, requiring only a slight differential pressure to fully open or close it. Check valves and needle valves, incorporating single function features of Flow Control Valve are also available. All valves made in 5 female pipe sizes: ⅛" to ¾". Valve bodies made from brass, aluminum, steel or stainless steel.



TIME DELAY CONTROL SWITCH FOR PRECISE DELAY OF WORK CYCLE

Provide controlled adjustable time dwell of solenoid operated air or oil supply valves. Range between ¼ and 60 seconds in 20 to 1 ratios. Compact—simple—foolproof—rugged Easily mounted on machine. Available for various types of actuation. Typical diagram below.




For Any Type Actuation Left or Right Hand (Left Hand Shown)
Type LU Upthrust
Type LH Horizontal
Type LR Roller
Type LD Downthrust
Type LB Direct

Write for catalogs and complete details

Pneu-trol DEVICES, INC.
Components for Automation
1436 N. Keating Ave., Chicago 51, Ill.

—ITEM 708—

WECKESSER

molded
BLACK NYLON
SCREWS
and
NUTS

Acid resistant . . .
Need no insulation . . .
Can't rust . . .
Can't corrode . . .

● **CUT ASSEMBLY TIME**

6-32, 8-32 and 10-32 in stock. Actual production samples will give you the whole story. Write on your letterhead.

WECKESSER COMPANY

5254 Avondale Ave. • Chicago 30, Ill.

—ITEM 709—

WALKER-TURNER

FLEXIBLE SHAFTING

This FREE Booklet will show you plenty of ways to improve product designs that include unaligned power drives and remote controls . . .

Mail the coupon back to us today for this free booklet. It will show you specific ways to eliminate complicated miter gears and many parts, ways to save space and make your products more compact, and ways to cut down on costs.

W-T Flexible Shafting can solve a good many of your power and control transmission problems. Put the problem right up to our W-T engineers, and they'll go to work on it without any obligation whatever.

WALKER-TURNER
DIVISION OF KEARNEY & TRECKER CORP.

Walker-Turner Division — Plainfield, New Jersey:
☐ Please send me FREE W-T Flexible Shafting Catalog and Data Sheets. M1-4
☐ Tell me more about your engineering service.

NAME _____ TITLE _____
COMPANY _____
STREET _____
CITY _____ ZONE _____ STATE _____

—ITEM 710—

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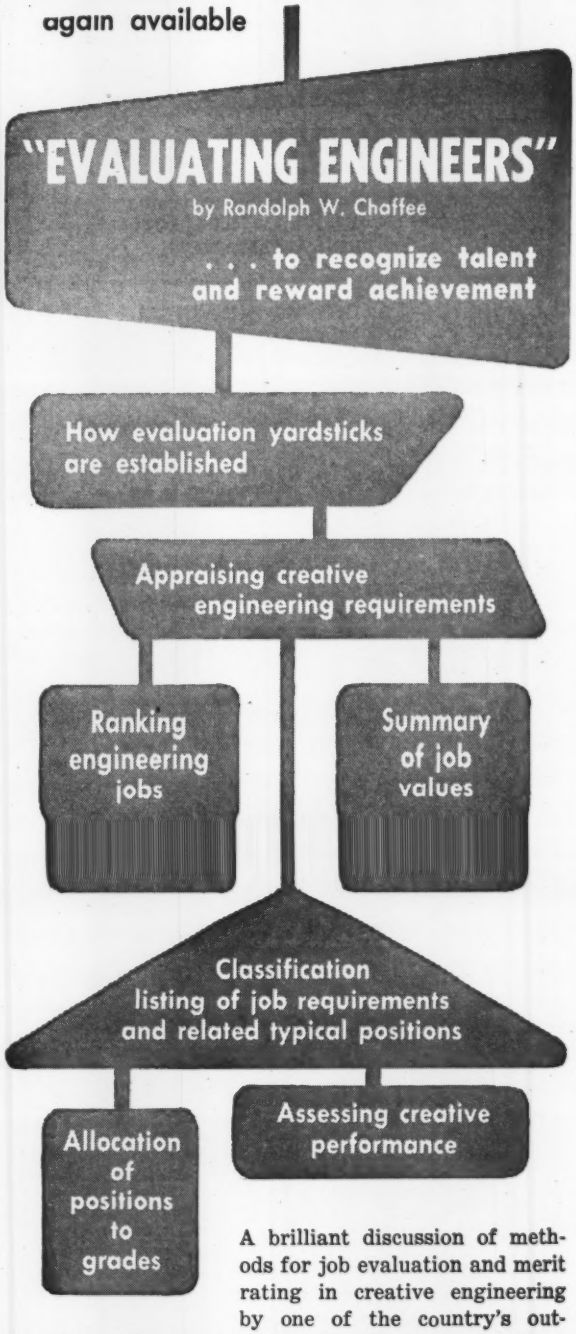
again available

"EVALUATING ENGINEERS"

by Randolph W. Chaffee

. . . to recognize talent and reward achievement


How evaluation yardsticks are established
Appraising creative engineering requirements
Ranking engineering jobs
Summary of job values
Classification listing of job requirements and related typical positions
Allocation of positions to grades
Assessing creative performance

A brilliant discussion of methods for job evaluation and merit rating in creative engineering by one of the country's outstanding authorities in this field. Use the order form below and get your copies while the supply lasts. Remittance with your order will greatly facilitate handling.

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(Add 3% to orders for delivery in Ohio to cover State Sales Tax.)

Parts made of

Dixon RULON

never need lubrication

Specify RULON for –

- VERY LOW FRICTION
- HIGH WEAR RESISTANCE
- GREAT CHEMICAL INERTNESS
- EXCELLENT DIELECTRIC PROPERTIES
- GOOD HEAT PROPERTIES UP TO 350°- 500°F

Rulon is inherently slippery, requires no lubrication. This remarkable plastic offers most of the advantages of Teflon but has far greater wear resistance and better resistance to cold flow.

If you need one or all of Rulon's special properties for bearings, bushings, slides, guides, cam followers, washers, spacers, or other parts — consult us without obligation.

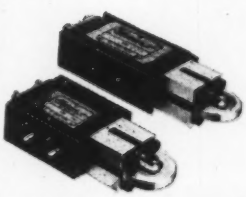
We supply both Rulon and Teflon in rods, tubes, sleeving, tape, extruded and molded shapes. Write for detailed information.

DIXON CORPORATION
BRISTOL 3, RHODE ISLAND

—ITEM 711—

Modernair

CRV SERIES ROLLER CAM VALVES



NEW Compact, Easy-Mounting Design!

FLAT SURFACES ALL AROUND, with convenient access to ports (all ⅛-27 NPT) make new CRV series valves easiest to "design into" your application. Ultra-compact—4-way is only 3/4" x 1-1/2" x 4-3/16" overall (roller cam extended).

STANDARD "O" RING SEALS throughout assure long, reliable service, are easily replaced when necessary.

CRV SERIES VALVES now available in 3 or 4-way hand lever, palm button, foot control, cam, roller or pilot-operated types. Prices range from $11.30 to $15.95, f.o.b. factory.

NO OTHER VALVE offers all these important features —why settle for less? Call your MODERNAIR dealer or write today for complete ddta.

Modernair Trademark CORPORATION

Dept. E-4, 400 PREDA ST., SAN LEANDRO, CALIF.
Member National Fluid Power Association 11

—ITEM 712—

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molded BRUSH CAPS

many types and sizes

supplied from stock

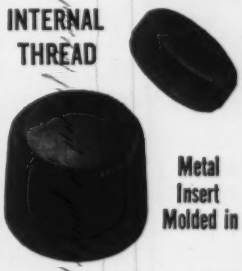
to help motor makers

build better motors

EXTERNAL THREAD?

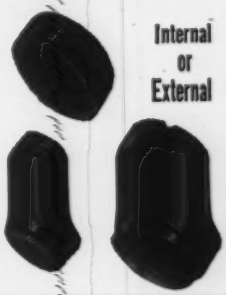
Metal Insert Molded in

INTERNAL THREAD



Metal Insert Molded in

MOLDED THREADS?



Internal or External

HOLDERS TO FIT?

Molded NYLON as well as Phenolic

External or Internal Threads

MOLDED COMMUTATORS?

with or without prongs

Send Blueprint for Quotation

Midwest Molding AND MANUFACTURING COMPANY

GURNEE 98 ILLINOIS

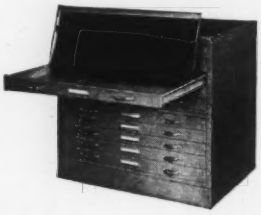
Chicago Phone: Dickens 2-0777
Long Distance: ONtario 2-1320

PLASTICS · TOOLING · COMPRESSION · INJECTION

—ITEM 713—

MAYLINE

MAYLINE
Metal Plan Files Intermember and Interlock!



All Mayline metal plan files intermember and interlock. Reinforced corners permit units to be stacked safely.

Drawers operate on ball bearing rollers and are equipped with attractive grey vinyl coated dust covers.

For information about stacking with files you now have, check dimensions shown in folder S-20, or write factory.

MAYLINE

MAYLINE

Symbol of Superiority

MAYLINE CO.

601 NO. COMMERCE ST.

SHEBOYGAN, WISCONSIN

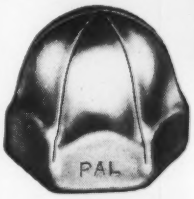
MAYLINE

—ITEM 714—

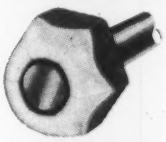
PUSH — IT'S ASSEMBLED!

—without threading, notching, cotter pins, etc.

PUSHNUT Trademark **FASTENERS**



TYPE C (Closed End)



TYPE K (Open End)

Low-cost decorative nuts push on unthreaded rod or rivets

Fast factory assembly—easy knockdown assembly—strong holding power

Tremendous savings are made in parts costs and assembly costs, wherever PUSHNUT Fasteners can be used. Factory assembly is speeded with magnetic holders for manual application or with assembly jigs and fixtures. Knockdown assembly requires only the tap of a hammer. Heat-treated, spring steel PUSHNUTS are being used on wheeled goods, playthings, chairs, ironing boards, paint rollers, spring-loaded devices, etc. Where can you use them? Sizes for .120", 5/32", 3/16", 1/4" and 5/16" unthreaded rod, in various finishes.

Send for free samples and bulletins.

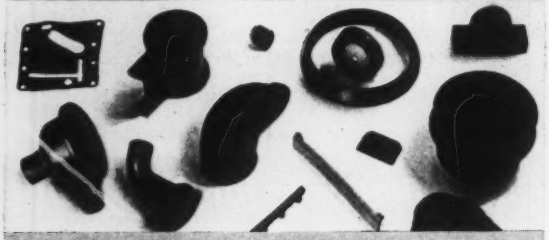
THE PALNUT COMPANY **75 Glen Road, Mountainside, N. J.**
Subsidiary of United-Carr Fastener Corporation
In Canada: P. L. Robertson Co., Ltd., Milton, Ont.

—ITEM 716—

Molded Rubber

A 20 MINUTE 16 mm FULL-COLOR SOUND FILM

An interesting, informative, professionally filmed color-sound picture that takes you through each operation in the production of precision-molded rubber products. Now released for general showing to industrial groups. Write for booking, stating date desired and alternate date.



Acushnet specializes in custom-engineered precision molded rubber parts made on order to customers' prints or specifications. Our broad experience in precision production can be applied to your requirements with economical results.

Send for Acushnet "Rubber Data Handbook."

Acushnet **ACUSHNET PROCESS COMPANY**
NEW BEDFORD, MASSACHUSETTS

... *Precision Molded* RUBBER, SILICONES - "APCOTITE" BONDING

Address all communications to 762 Belleville Ave., New Bedford, Mass.

—ITEM 715—

Machine Designers

Draftsmen

• Promotions within our company have created a number of opportunities for qualified men to grow with our growing engineering organization.

If you'd like a career with a real future, with a long established company that's widely known as a good place to work, write or visit us now!

Write: C. T. Blake, Mgr.
Engineering Department

WARNER & SWASEY CO.
5701 Carnegie Avenue, Cleveland 3, Ohio

—ITEM 717—

ENGINEERS
AVAILABLE OR WANTED

WANTED: Advertising Man for Technical Products. Previous advertising experience not necessary but helpful. Must have at least two or three years of college with courses in engineering and technical subjects and like to write. If you have the qualifications we have an opportunity open for you. Man selected will be trained in all phases of industrial advertising. In your letter of application state age, education, positions held, and give statement of why you want a career in advertising. Location: well-known Connecticut company. Address Box 894, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

WANTED: Mechanical Engineers to design and develop fixtures and automatic machinery for production of electronic components. BS or MS degree in mechanical engineering required along with experience in jig or machine design. These are responsible positions with one of the leading and fastest-growing manufacturers of precision-built electronic units. Please submit resume of your educational background and experience to Transitron Electronic Corporation, 407 Main Street, Melrose, Massachusetts.

WANTED: Mechanical Engineer (Sales). Graduate M.E. or equivalent for sales position with expanding recognized power press industry. Outstanding opportunity for energetic young engineer 25 to 35 years of age who is interested in an engineering sales career. Sales territory available after interesting training program is completed. Applications will be treated in strict confidence and should contain a complete resume of your personal and work histories. Address all replies to Box 896, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

WANTED: Machine Designers and Design Engineers wanted for permanent positions. Design experience desired in either paper converting machinery, box manufacturing equipment or packaging equipment. Excellent working conditions and opportunity for advancement. Address Box 897, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

The Product Design Engineer can always find a complete encyclopedic source of supply for component parts, materials or equipment in—

THOMAS REGISTER

Thomas Publishing Company
461 Eighth Avenue, New York 1

—ITEM 718—

A complete line of power transmission equipment, using one bushing system . . .

Browning is your one source for an integrated line of V-belts and sheaves, roller chain and sprockets, paper pulleys, and rigid, flexible and chain couplings. The entire system employs Browning's unbreakable malleable split taper bushing, which mounts and unmounts easily but won't loosen in usage. Saves time, lowers costs. Thousands of size and bore combinations. Ask Browning distributor or write us for free *Catalog GC101.*

Browning MANUFACTURING COMPANY
MAYSVILLE, KENTUCKY

—ITEM 719—

BALTRIC

THE BANTAM THAT PACKS A HEAVYWEIGHT PUNCH

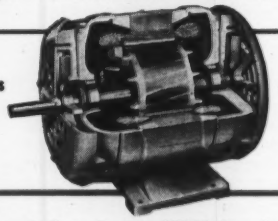
The new *Streamcooled Baltric* line of completely enclosed motors are champions, every one, all sinew and muscle . . . compact, powerful, efficient. Advanced engineering using the newest materials, enables Baltric to offer you hard-working power packages.

These are tomorrow's motors today! Greater efficiency with less weight and bulk . . . insulation is lighter and better.

Built to NEMA standards, Baltric's your best bet . . . doesn't waste space . . . doesn't waste weight . . . easier to handle and install.

BESS-8

- Exclusive One-piece Stator Frame
- Rotor Provides Improved Torque Characteristics
- Solid End Plates Completely Enclose Motor
- Base Design Permits Flexibility In Installing Or Replacing



Original *Streamcooled* Motors Also Available—Built to Former NEMA Standards

ALL *BALTRIC* MOTORS TOTALLY ENCLOSED AND *STREAMCOOLED*

BALDOR ELECTRIC COMPANY

Baltric Motors Are Available In Polyphase • Squirrel Cage • Induction and Single Phase • Capacitor Start • Induction Run Types

4353 DUNCAN AVENUE • ST. LOUIS 10, MISSOURI

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MACHINE DESIGN

Penton Building, Cleveland 13, Ohio
Main 1-8260

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Richard A. Templeton
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Pauline J. Herndon
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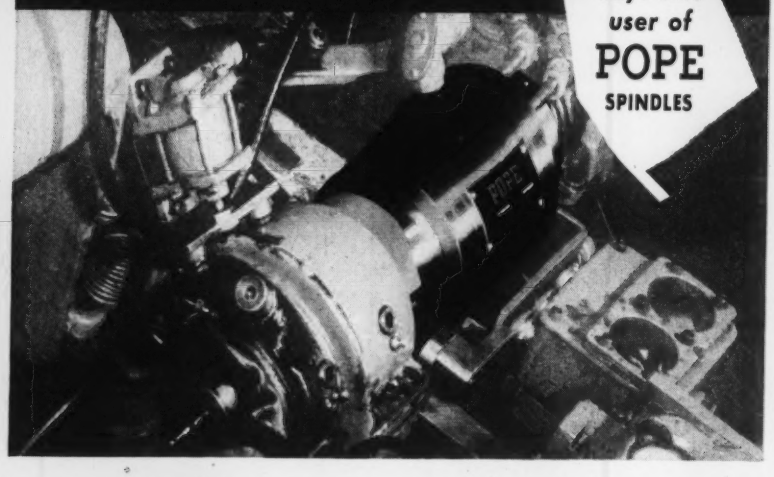

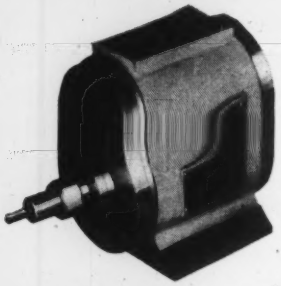

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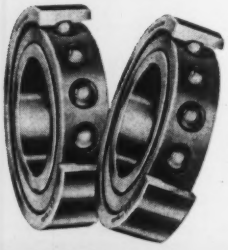

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Cam Design and Production Procedures
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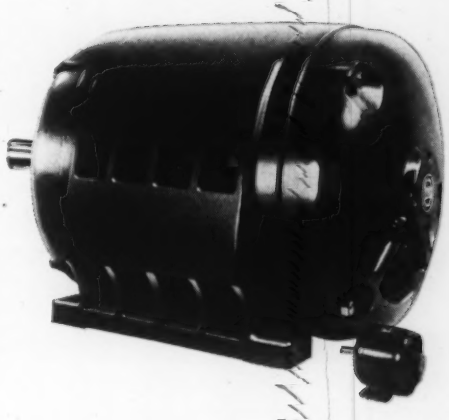

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